BOEING

International Space Station Alpha Program

D684-10020–1

Program Master Integration and Verification Plan

Revision A

May 8, 1995

National Aeronautics and Space Administration
Johnson Space Center
Contract No. NAS15–10000 (DR MG05)

REVISION AND HISTORY PAGE

REV.	DESCRIPTION	PUB. DATE
	INITIAL RELEASE APPROVED BY NASA TPR	03–23–94
A	REVISION A, (INCORPORATES ECP 38, ECP 109, ECP 117, ECP 118, AND DOCUMENT RESTRUCTURING FOR CLARITY UNDER ECP 145.)	05–08–95

PREFACE

The Space Station Program Master Integration and Verification Plan (PMI&VP) D684–10020–1 provides the top level approach and planning for the integration and verification of the International Space Station Alpha (ISSA) System. This document is prepared in accordance with the Prime's SOW DR MG05. This document includes the philosophies and process descriptions which, when implemented, assure compatibility between integration and verification planning, implementation and scheduling conducted by the Prime Contractor, the three Tier 1 Subcontractors, and the International Participants (IPs). This document is used as a source or reference for the Bilateral Integration and Verification Plans (BI&VPs) development.

The contents of this document are intended to be consistent with the tasks and products to be prepared by Program participants. The PMI&VP may be applicable on new ISSA contractual activities and may be implemented on existing contracts through contract changes. This document is under the control of the System Analysis and Integration Team (SAIT), and any changes or revisions shall be approved by the SAIT and the Contracting Office Technical Representative (COTR). Following baselining, this document may be modified only through contract change. Such revisions are expected to be consolidated and incorporated approximately once per year.

/s/

Co–Chairman, SAIT Date
International Space Station Alpha

/s/

Co–Chairman, SAIT Date
International Space Station Alpha

/s/

Contracting Office Technical Representative Co–Chairman,Date
International Space Station Alpha

INTERNATIONAL SPACE STATION ALPHA PROGRAM

PROGRAM MASTER INTEGRATION AND VERIFICATION PLAN

MAY 8, 1995 REVISION A

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INTERNATIONAL SPACE STATION PROGRAM

PROGRAM MASTER INTEGRATION AND VERIFICATION PLAN

LIST OF CHANGES

MAY 8, 1995 REVISION A

All changes to paragraphs, tables, and figures in this document are shown below:

SSCBD	ENTRY DATE	CHANGE	PARAGRAPH(S)
	May 8, 1995	REVISION A	ALL
			TABLE(S)
			FIGURE(S)
			APPENDIX(ES)
			ADDENDA

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1.0 INTRODUCTION

The ISSA system consists of a manned orbiting facility and a ground based system. The manned orbiting facility accommodates engineering research, microgravity research, and life and natural sciences research. The ground based system provides support to the orbiting facility that includes services (e.g., resupply, communications) and personnel.

The ISSA program is a cooperative effort between the United States (U.S.) and several International Participants. The necessary agreements are established at the State Department level of the participating countries. These agreements are documented by Intergovernmental Agreements (IGAs) and/or Memoranda of Understanding (MOUs).

Since the ISSA Program consists of multi–national organizations with differing interpretations of terminology, integration and verification definitions, as used within this document, are:

> Integration – The act of mating hardware and/or software components, subsystems, systems or elements at their respective interfaces and verifying the compatibility and proper operation of the resulting entity. Integration, as used in this document, is an integral part of the verification process.
>
> Verification – A set of activities performed to ensure that facilities, hardware and software products, and operational and acceptance procedures comply with the requirements imposed upon them.

Additional definitions for other terms are found in Appendix B.

1.1 SCOPE

The general term “Verification” is used in conjunction with different types of activities e.g. – specification compliance, procedure, task, interface, payload, acceptance, assembly, and checkout.

This document deals with specification compliance (including interface) verification as it applies to NASA’s Prime Contractor for the ISSA Program and associated U.S. On–orbit Segment Specification (USOS) GFE. Qualification and acceptance activities are described in section 6. The other aspects of the general term “Verification” are described in section 9 of this document and are included there for clarity. The owners of these related activities are responsible for verification of their products or tasks against their derived requirements.

Specifically, this document addresses specification compliance verification of the ISSA system, USOS, and USOS side of the interfaces with the IPs, U.S. Ground Segment (USGS) and the National Space Transportation System (NSTS). (See Figure 1–1). The IPs, USGS and NSTS are responsible for verification of their side of the interface.

This document will apply to joint testing, as shown on Figure 1–1, between the USOS and the IPs, USGS and NSTS as agreed to in the applicable joint plans (e.g., Bilateral Integration and Verification plans), and to new or modified GFE and USGS end items.

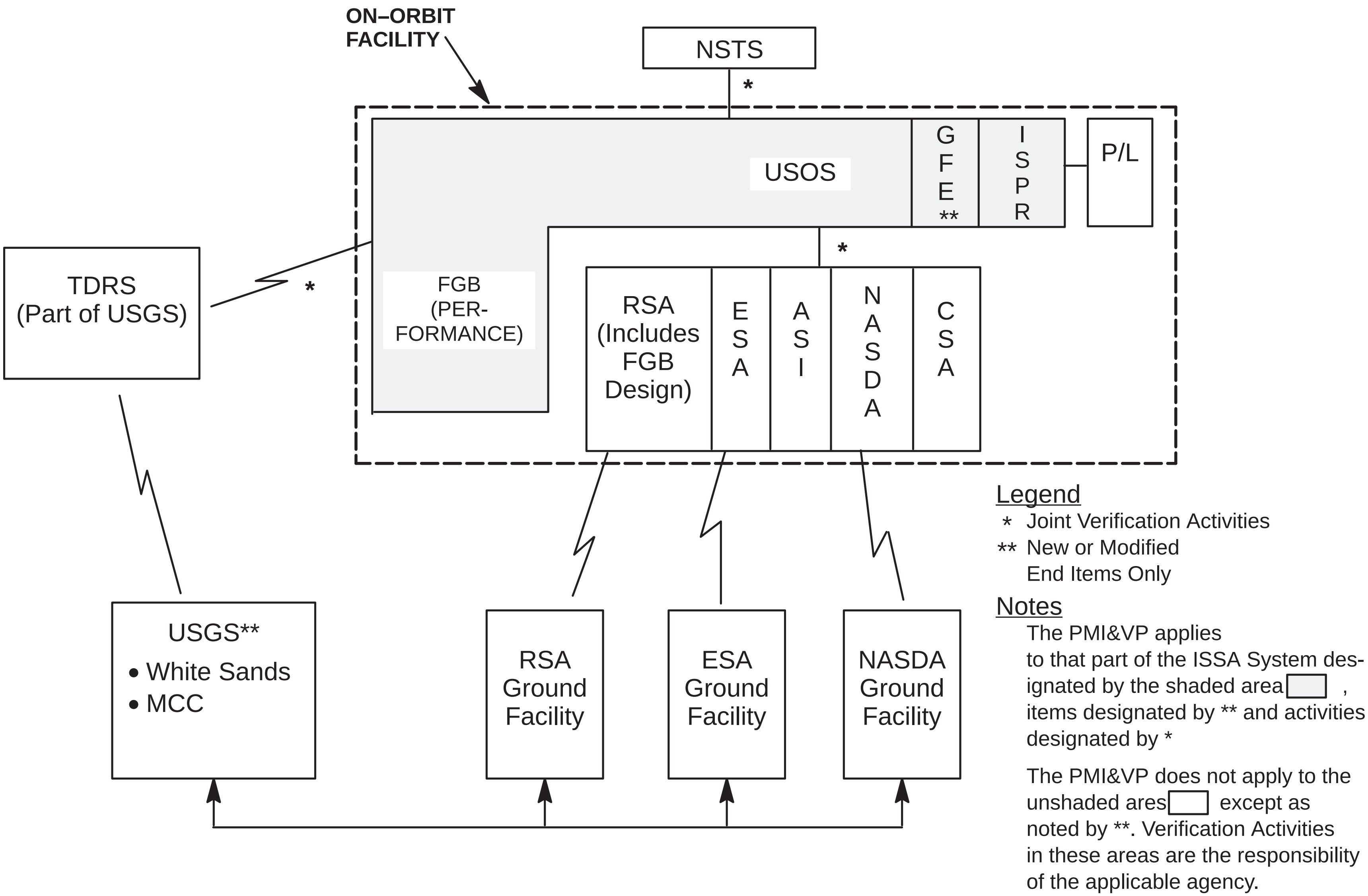


FIGURE 1–1 ISSA SYSTEM OVERVIEW – PMI & VP APPLICATION

Verification of ISSA payloads and the integration of these payloads, including joint activities with the ISSA program, are the responsibility of the payload community.

This document also includes the process for traceability of all segment requirements to the ISSA System specification (concept is portrayed in Figure 3–2).

1.2 PURPOSE

The objective of the verification program is to assure that the technical requirements of the program have been met.

This document establishes the planning, philosophy, and approach that, when applied, will confirm the ISSA system and U.S. On–orbit end items comply with specifications, function properly as integrated units, and are ready for their intended use. This plan also establishes NASA's Prime contractor's approach for the interface verification with the USGS, with the NSTS (Shuttle), and with international segments to assure compliance with the ISSA system specification.

This document establishes the planning, processes, and controls and defines the objectives of the specification verification compliance program, including definition of the methods for achieving those objectives. It also identifies the program participants and establishes the verification roles, responsibilities, and relationships with respect to the Prime Contractor, International Participants, and NASA, and includes the approach for facilities certification and Support Equipment (SE) verification or certification.

In addition, this document describes the Program Verification Information System (PVIS) which is the database for collecting and generating compliance information necessary to prove satisfaction of system, segment, and end item specification requirements.

This document describes the verification processes used by NASA's Prime Contractor and the Prime Contractor's Tier 1 Subcontractors.

1.3 AUTHORITY AND PRECEDENCE

The authority for this document is derived from the Prime Contractor Statement Of Work (SOW), NAS15–10000, as defined by DR MG05. Where this document conflicts with contract provisions the contract provisions shall take precedence. Where the Integration and Verification Implementation Plan (I&VIP), and Product Group (PG) and Lockheed verification documents conflict with this document, this document shall take precedence.

2.0 DOCUMENTS

The following documents of the date and issue shown include specifications, models, standards, guidelines, handbooks, and other special publications.

The documents in this paragraph are applicable to the extent specified herein. Inclusion of applicable documents herein does not in any way supersede the order of precedence identified in paragraph 1.3.

DOCUMENT NO.	TITLE
D684–10002–1	Space Station Program Data Management Plan
D684–10097–1 Draft	Functional Configuration Audit (FCA) / Physical Configuration Audit (PCA) Plan
D684–10017–1 April 8, 1994 Baseline Issue	Prime Contractor Software Development Plan
D684–10018–1 April 16, 1994 Baseline Issue	United States On–Orbit Segment Prime Contractor Interface Control Plan
D684–10021–1 October 18, 1994 Baseline Issue	Program Verification Information System Process Document
SW684–10022–1 October 13, 1994 Baseline Issue	Program Verification Information System Software Requirements Specification
D684–10025–1 March 21, 1994 Baseline Issue	Integration and Verification Implementation Plan for U.S. Segments
D684–10041–1–5 October 14, 1994 Draft	ISSA Integrated Logistics Support Plan, Volume 1, Support Equipment Plan, Book 5
D684–10044–1 June 6, 1994 Baseline Issue	Program Execution Plan
D684–10046–1 Draft	Prime Configuration Management Handbook
D684–10054–1 September 12, 1994 Baseline Issue	Risk Management Plan
D684–10200–1 January 3, 1995	ISS Functional Decomposition Document

DOD–STD–2168 April 29, 1988 Baseline Issue	Defense System Software Quality Program
MIL–HDBK–286 December 14, 1990 Baseline Issue	A Guide for DOD–STD–2168 Defense System Software Quality Program
MIL–STD–975 February 19, 1993 Rev K	NASA Standard Electric, Electronic, and Electro–mechanical (EEE) Parts List Military Standard for Systems
MIL–STD–1521 June 4, 1985 Rev B, Notice 1	Technical Reviews and Audits for Systems Equipment, and Computer Software
NHB 1700.1 (VI–B) June 1993 Baseline Issue	NASA Safety Policy and Requirements Document
NHB 2340.4 June 7, 1994 Rev A	Contractors Metrics Handbook
SSP 30223 November 7, 1994 Rev F	Problem Reporting & Corrective Action System Requirements
SSP 30233 April 17, 1994 Rev D	Space Station Requirements for Materials and Processes
SSP 30312 March 23, 1994 Rev E	Electrical, Electronic, and Electromechanical Parts Management and Implementation Plan for Space Station Program
SSP 30473 Draft	Payload Verification Program Plan
SSP 30559 September 30, 1994 Baseline Issue	Structural Design and Verification Requirements
SSP 30695 Baseline Issue	Acceptance Data Package Requirements Specification
SSP 41000 January 16, 1995 Rev B	System Specification for the International Space Station
SSP 41161 August 2, 1994 Baseline Issue	Segment Specification for the U.S. Ground Segment Type A

SSP 41162 December 9, 1994 Rev A	Segment Specification for the U.S. On–orbit Segment
SSP 41170 April 4, 1994 Baseline Issue	Configuration Management Requirements
SSP 41171 April 5, 1994 Baseline Issue	Preparation of Program – Unique Specifications
SSP 41172 March 23, 1994 Baseline Issue	Qualification and Acceptance Environmental Test Requirements
SSP 41173 November 7, 1994 Rev A	Space Station Quality Assurance Requirements
SSP 50004 June 17, 1994 Baseline Issue	Ground Support Equipment Design Requirements
SSP 50011–1 December 8, 1994 Rev B	Concept of Operation and Utilization (COU), Volume 1, Principles
SSP 50011–2 April 4, 1994 Baseline Issue	Concept of Operation and Utilization (COU), Volume 2, Profiles and Scenarios
SSP 50011–3 November 29, 1994 Baseline Issue	Concept of Operation and Utilization (COU), Volume 3, Processes
SSP 50123 February 10, 1995 Baseline Issue	Configuration Management Handbook

2.1 REFERENCE DOCUMENTS

The following documents are referenced within this document and apply to the extent specified herein.

D683–10072 March 20, 1995 Baseline Issue	Boeing (Huntsville) Master Verification Plan
D684–10500–1 March 17, 1994 Baseline Issue	Command and Data Handling Architecture Description Document

D684–10501–1 March 17, 1994 Baseline Issue	Communication & Tracking Architecture Description Document
D684–10502–1 March 18, 1994 Baseline Issue	Extra–Vehicular Activity Architecture Description Document Document
D684–10503–1 March 18, 1994 Baseline Issue	Extra–Vehicular Robotics Architecture Description Document
D684–10504–1 March 17, 1994 Baseline Issue	Failure Detection, Isolation and Recovery Architecture Description Document
D684–10505–1 March 17, 1994 Baseline Issue	Flight Crew Systems Architecture Description Document
D684–10506–1 March 18, 1994 Baseline Issue	Guidance, Navigation & Control/Propulsion Architecture Description Document
D684–10507–1 March 16, 1994 Baseline Issue	Launch Package Baseline Configuration Document Overview
D684–10508–1 March 17, 1994 Baseline Issue	Life Support Architecture Description Document
D684–10509–1 March 18, 1994 Baseline Issue	Power Architecture Description Document
D684–10510–1 March 18, 1994 Baseline Issue	Structures Architecture Description Document
D684–10511–1 March 18, 1994 Baseline Issue	Thermal Control Architecture Description Document
D684–10700–1 April 8, 1994 Baseline Issue	Boeing Defense & Space Group, Missiles & Space Division, Product Team Handbook
SSP 50033 Draft	NASA–CSA Bilateral Integration and Verification Plan
SSP 50034 Draft	NASA–ESA Bilateral Integration and Verification Plan

SSP 50035 Draft	NASA–NASDA Bilateral Integration and Verification Plan
SSP 50102 Draft	NASA–ASI Bilateral Integration and Verification Plan
SSP 50101 Draft	NASA–RSA Phase 2 Bilateral Integration and Verification Plan
KSC–STA–50 Draft	KSC Processing Plan
MDC 94H0540 Draft	McDonnell Douglas Master Verification Plan
RI/RD88–607 Draft	Rocketdyne Master Verification Plan
TBD	FGB Verification Plan
NSTS 14046 April 1, 1994 Rev C	Payload Verification Requirements

3.0 INTERNATIONAL SPACE STATION ALPHA PROGRAM DESCRIPTION

3.1 ISSA SYSTEM OVERVIEW

The ISSA is an international endeavor resulting from a partnership among participating countries; Canada, participating member countries of the European Space Agency, Italy, Japan, Russia, and the United States. NASA, representing the United States, is responsible for the overall management of the program. The ISSA consists of the on-orbit space vehicle and the associated ground support systems required to construct, operate, maintain, and use the ISSA.

The orbiting facility portion of the ISSA is composed of pressurized and non–pressurized elements supplied by the United States and IPs. The IPs are represented by the Agenzia Spaziale Italiana (ASI), the Canadian Space Agency (CSA), the European Space Agency (ESA), the National Space Development Agency of Japan (NASDA), and the Russian Space Agency (RSA). The orbiting facility is constructed on–orbit according to an assembly sequence that provides increasing ISSA capabilities in phases.

The U.S. elements are comprised of the Integrated Truss Assembly elements, Solar Arrays, Resource Nodes, Functional Energy Block (FGB) (a Russian item procured by the Prime, for NASA), and the Laboratory and Habitation Modules. These elements are provided by the Prime and its subcontractors.

The major elements provided by the IPs are the Mini–Pressurized Logistics Module (MPLM), provided by the ASI; the Japanese Experiment Module (JEM), provided by NASDA; Columbus Orbiting Facility (COF) and the Automated Transfer Vehicle (ATV), provided by ESA; the Space Station Remote Manipulator System (SSRMS), Mobile Remote Servicer (MRS), Mobile Base System (MBS), and Special Purpose Dextrous Manipulator (SPDM), provided by CSA; and the Docking Compartment, Universal Docking Module, Science Power Platform (SPP), Service Module, Cargo Vehicle, Research Modules, Docking and Stowage Module (DSM) and the Soyuz Assured Crew Return Vehicle (ACRV), provided by RSA.

Ground support systems are the facilities and equipment that provide the capability to test, control, monitor, maintain, operate, and use the ISSA. The ground support systems include the U.S. Ground Segment (USGS) and the IPs' ground segments.

The USGS consists of the ground–based facilities and equipment that support the ISSA and its payloads during on–orbit assembly operations and utilization. The USGS also provides for training, operations planning, resupply of consumables, and the processing of payloads and waste returned from orbit.

Each of the IPs provides ground based facilities to support ISSA operations and utilization. The International Participants ground systems will be networked with the USGS to exchange audio, video, data, and payload command and data files.

3.1.1 ISSA PROGRAM PHASES

Figure 3–1 depicts the program phases for each space station launch package/stage. This is an iterative process that continues until assembly of the total station is completed.

Figure 3–1 includes a brief description of what major program activities occur from a Launch package and stage view point, overlaid with what the different verification activities are that occur during each phase. As shown on Figure 3–1, system, segment, and end item specification compliance and various types of procedure verification occurs throughout the first two program phases on a stage–by–stage basis leading up to Space Station Assembly Complete. Realistically, the phases actually overlap; the demarcation is not as clean as depicted in the Figure.

3.1.2 ISSA SYSTEM DOCUMENTATION

3.1.2.1 SPECIFICATIONS

SSP 41171, Preparation of Program–Unique Specifications, is the standard used on the ISSA program for preparing all system, segment and end–item level specifications. For each specification, design and performance requirements are contained in section 3 of the specification and verification requirements (quality assurance provisions), except for ESA and NASDA segments, are established in section 4 of the specification. For the COF, JEM, ATV and International Standard Payload Rack (ISPR) Interface Requirement Document (IRD)s, and the FGB Interface Control Document (ICD) Part 1's, design and performance requirements are found in section 3 of these documents and the corresponding quality assurance provisions (for joint verification requirements) in section 4.0. Quality assurance provisions that are the responsibility of either the IP or the U.S. are documented in IP and U.S. segment and end item specification section 4s, and are also collected into an Interface Verification Visibility Report (IVVR) to support U.S./IP data exchange. For a detailed description of the IVVR, See section 5.4.

The top level ISSA system requirements, documented in the ISSA System Specification, form the foundation for the functional decomposition and top down allocation of requirements through the specification hierarchy to the lowest level specifications in ever increasing detail. See Figure 3–2. The verification requirements traceability process follows the reverse of the top down allocation process tracking each lower level (child) requirement to the higher (parent) source requirement. The closure (verification) of all requirements is accomplished with a "bottoms up" approach from the implementation level to the system level, using the requirements traceability process. (See paragraph 5.2 for a more detailed description.)

The ISSA specification hierarchy is depicted in Figure 3–2. In addition to the IRDs and ICDs summarized below, the system and segment specifications listed below also reference NASA and commercial standards imposed on the ISSA design.

System Specification

Segment Specifications:

a. United States On–orbit Segment

b. European Segment

c. Japanese Experiment Module Segment

d. Russian Segment

e. Italian Mini–Pressurized Logistics Module Segment

f. Canadian Mobile Servicing System Segment

g. United States Ground Segment

IRDs:

a. ISPR IRD (common to ESA, NASA, and NASDA)

b. Space Station Manned Base (SSMB) to ATV IRD

c. SSMB to COF IRD

d. SSMB to JEM IRD

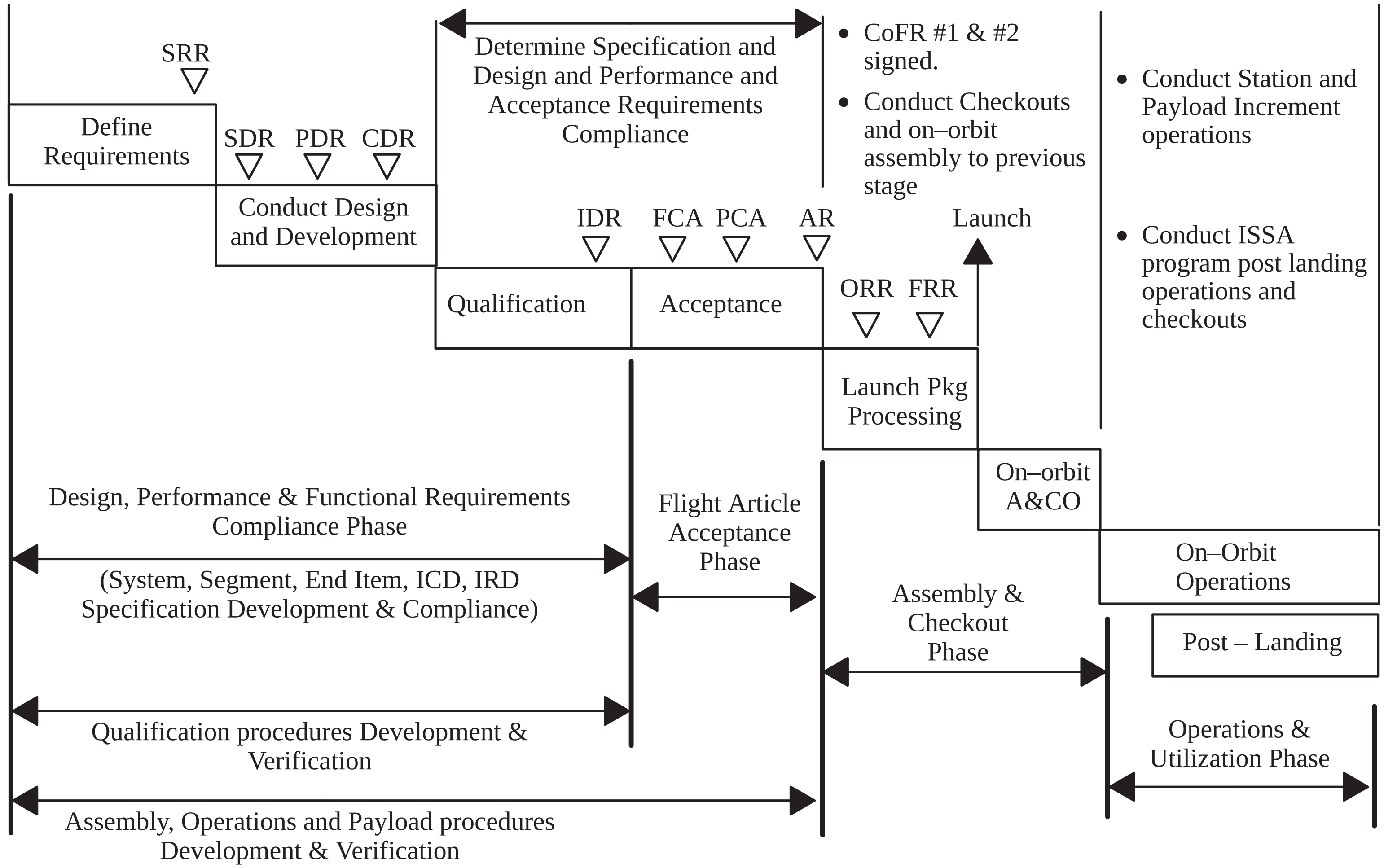
ICD Part 1s:

a. RSA to U.S. only

b. For a complete listing of applicable ICDs, refer to the Interface Control Plan, D684–10018–1.

Stage Requirements:

Stage unique or assembly integration requirements, contained in Assembly Integration Requirements Documents are established for each stage of the station assembly process and are described in Section 4.0. These requirements are flowed down and incorporated into the end item specifications. Details associated with how these requirements are implemented are found in Section 5 of this document.



Note: 1. Launch package and stage oriented, iterative for each launch package and stage

FIGURE 3–1 PROGRAM PHASES

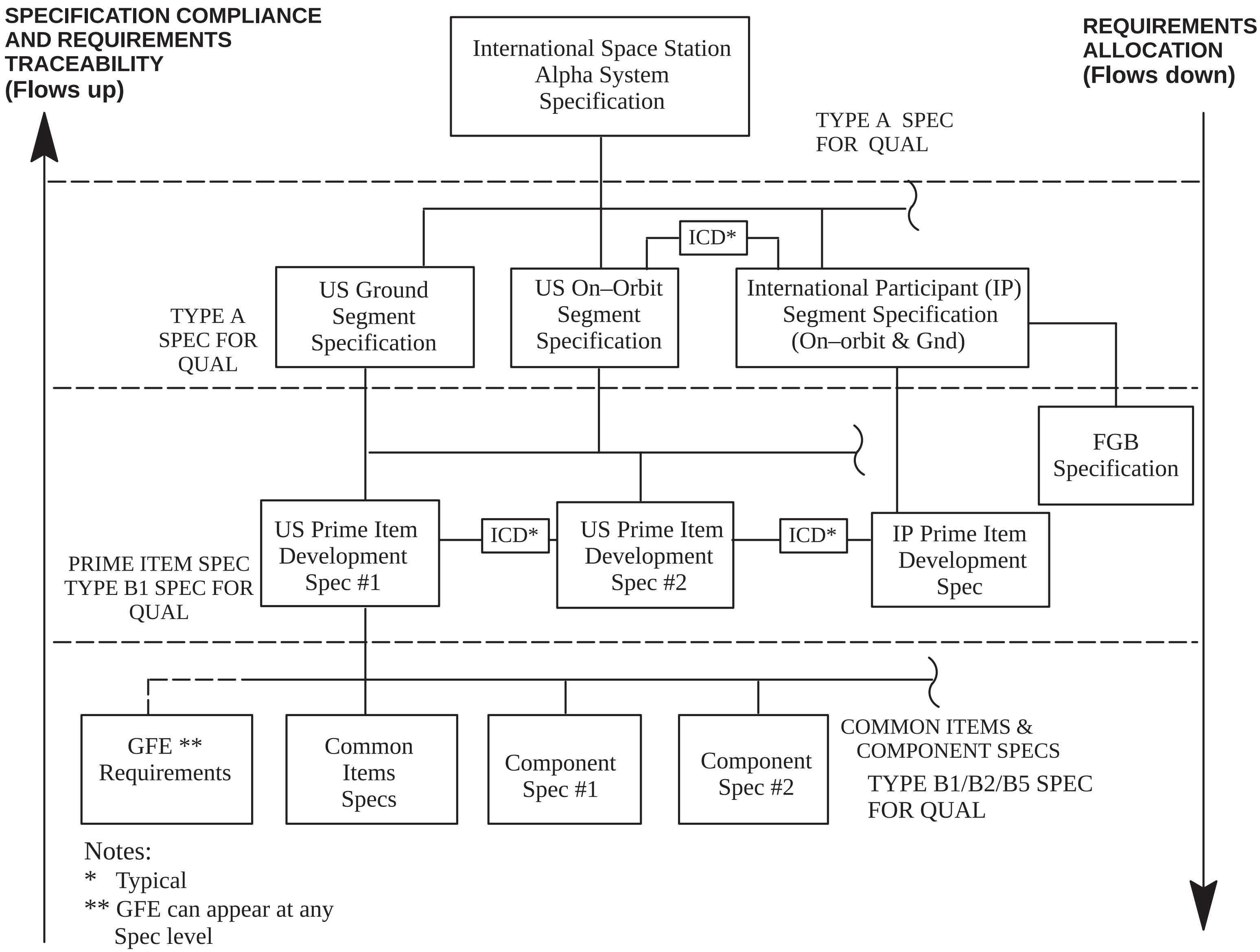


FIGURE 3–2 ISSA SPECIFICATION TREE

3.1.2.2 VERIFICATION PLANS

In addition to the shared development of top–level specification and interface verification requirements, the U.S. and IPs develop a set of verification plans to describe the processes, products, activities, agreements, and resources used in the ISSA vehicle and U.S./IP joint interface verification. A similar set of plans are developed in conjunction with the NSTS and USGS. Figure 3–3 depicts these plans and shows their relationship to each other.

A description of these plans is found in paragraph 4.4 of this document.

3.2 VERIFICATION PROGRAM OVERVIEW

3.2.1 INITIAL ISSA VERIFICATION PROGRAM CONSIDERATIONS

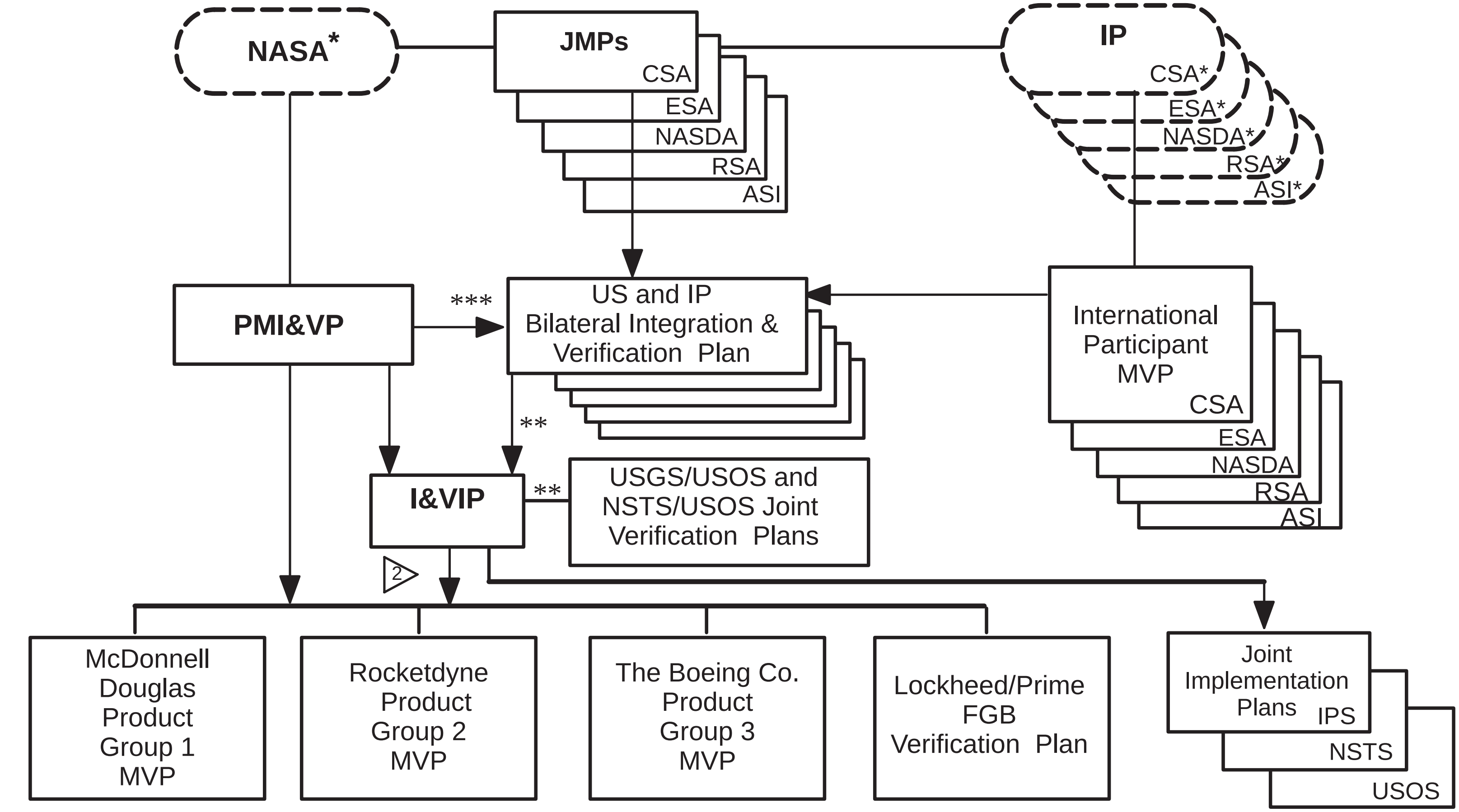
The major consideration affecting the U.S. portion of the initial ISSA verification program approach was the fixed annual funding profile. This funding profile limits the end–item to end–item test program, thereby increasing the risk of performing specification compliance. As a result, there was a strong desire to use facilities and assets that were already in place to reduce cost and maximize schedule efficiency.

3.2.2 VERIFICATION PROGRAM APPROACH

The basic Verification Program philosophy is to integrate and test on the ground what we fly before we fly within the constraints imposed by geography, cost and schedule. The Verification Program approach supporting this philosophy is to conduct testing at the lowest possible levels and to complete specification compliance verification prior to end-item shipment of the end-item from the factory. This means that specification compliance start at the lowest levels and builds to the ISSA level. It does not mean that testing at the Segment and System level is precluded. Each of the organizations responsible for development of an item is responsible for the verification of that item to its specified requirement.

As a result of the initial program considerations, however, the Verification Program's primary method employed to satisfy the USOS Segment and System Level Specifications, is verification by analysis. A verification by analysis approach is perceived as a high risk to the success of the ISSA. Therefore, the ISSA verification program approach includes risk reduction processes and activities.

Two processes are used to define ways to reduce the risk associated with the Segment and System Level verification program; the Five-step process and the Element-to-Element Systems Interface Integrity process. Both of these processes are described in subsequent paragraphs in this document.



* Agencies
** Joint activities
*** Process data

Note: 1 Government Furnished Equipment and Facility Verification Plans not shown.

2 PG updates

Legend:

MVP	=	Master Verification Plan
JMP	=	Joint Management Plan
PMI&VP	=	Program Master Integration and Verification Plan
I&VIP	=	Integration and Verification Implementation Plan
NSTS	=	Shuttle
USGS	=	U.S. Ground Segment

FIGURE 3–3 SPECIFICATION COMPLIANCE PLANNING DOCUMENTATION TREE

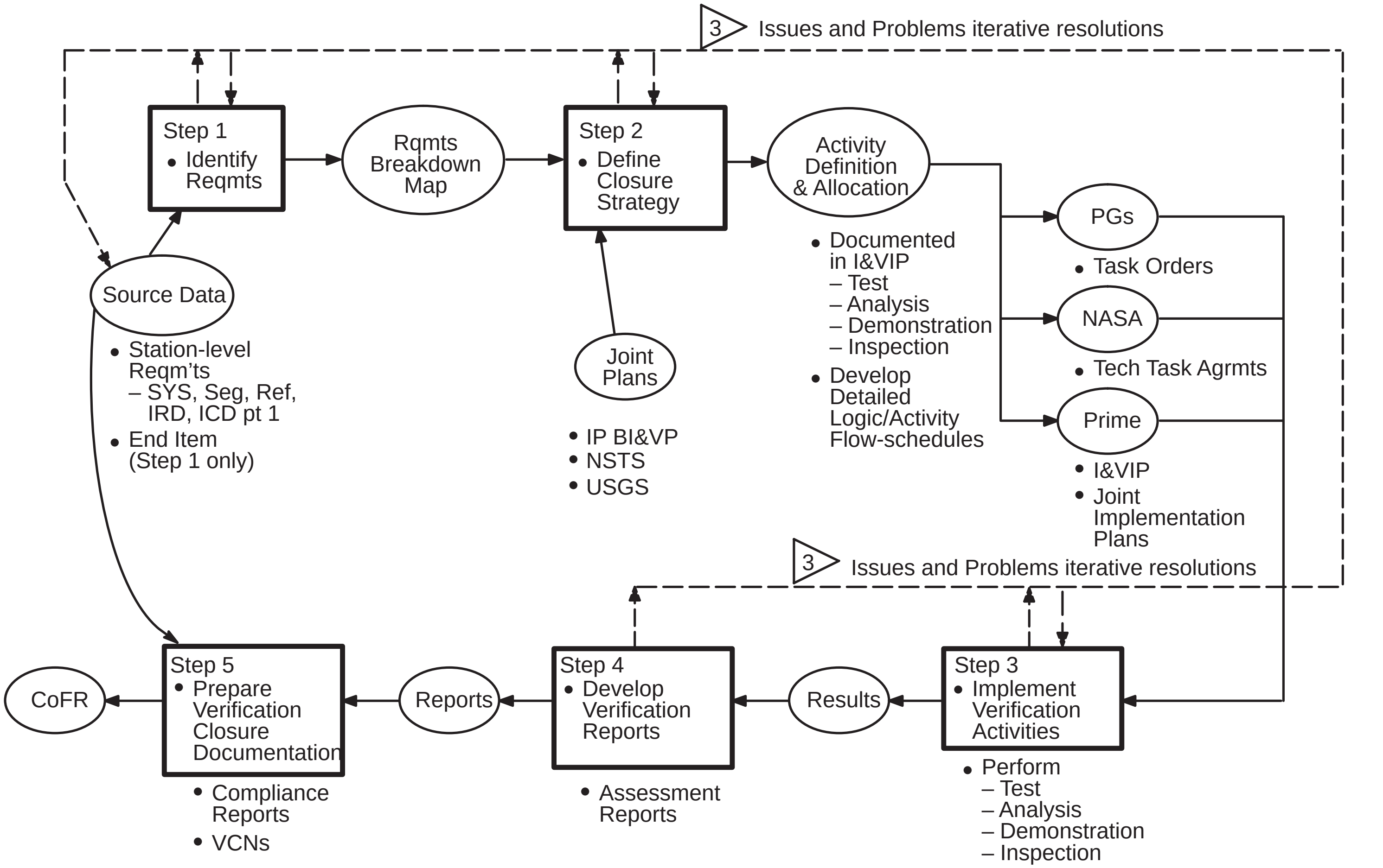
3.2.2.1 FIVE–STEP VERIFICATION PROCESS (SPECIFICATION COMPLIANCE)

Once the initial allocation and flowdown of requirements has been established, the five-step verification process is initiated. The five-step verification process structures specification compliance activities from the lower levels to higher levels of verification within the ISSA program. The five-step verification process is summarized on Figure 3–4 and discussed in greater detail in sections 5, 6, and 7 of this document.

This five-step verification process is the check and balance which assures that the initial System and Segment level verification requirement and derivation is correct. It establishes the detailed verification strategy for each requirement which is the basis for the verification program (e.g., a verification requirement in the USOS Specification may call for analysis, but the Five-step Verification Process may show that a test is required because there is not sufficient data available to support the analysis.)

3.2.2.2 ELEMENT–TO–ELEMENT SYSTEMS INTERFACE INTEGRITY

The EESII Quantitative Functional Analysis (QFA) process was developed as a way to identify methods for reducing risk. This analysis will provide information pertinent to the fidelity of the interface testing performed by the Product Groups. It is expected that the analysis will show where interface testing can be enhanced or where flight hardware to flight hardware functional tests should be performed to reduce the risk of these items not performing properly on–orbit. Essentially, the QFA determines the complexity of ISSA interfaces and systems and examines to what extent ISSA subsystem interfaces are demonstrated and tested. This, in turn, shows which interfaces are not tested adequately. A more detailed explanation of the QFA is contained the I&VIP.



NOTE 1: Data derived from this process is documented in the PVIS as described in Sections 5, 6, & 7 of this document and reported to the program via DRs VE–20 and VE–24

2: Deviations and waivers may result througout the process.

3 Issues/Problems can occur at any time during the first 4 steps of the process. Resolution of these items is iterative back through previous steps and source data as required.

FIGURE 3–4 FIVE-STEP VERIFICATION PROCESS

4.0 VERIFICATION MANAGEMENT

This Section addresses verification team organization, roles and responsibilities, processes, and a description of the verification products.

4.1 VERIFICATION TEAM ORGANIZATION

The verification program is managed according to the Analysis and Integration Team/Integrated Product Team (AIT/IPT) program philosophy, as established in the Program Execution Plan (PEP).

The PEP also defines program management processes. The current Prime/NASA AIT/IPT organizational structure, is shown in Figure 4–1. Subtiered to the System AIT (SAIT), and the Vehicle AIT (beneath the Vehicle IPT) are the Verification AITs. The SAIT and VAIT verification AITs are combined into one team called the Integrated Test and Verification Team (IT&V). This team has verification responsibility to the SAIT and VAIT and is responsible for verifying that the ISSA System is a fully functional orbiting platform. The IT&V team is also responsible for ensuring that the verification processes are understood and that these processes are properly implemented.

4.2 VERIFICATION ROLES AND RESPONSIBILITIES

4.2.1 INTEGRATED TEST & VERIFICATION TEAM

The IT&V team leads the verification of the ISSA system, providing direction to the PGs and Lockheed Missile and Space Company (LMSC) and coordination with other program participants (NSTS, USGS, IPs, etc). Teams which provide verification activities for verification, assembly, and checkout will do so in conjunction with the IT&V team. The IT&V team's execution of verification activities is described in the Integrated Test and Verification Team Execution Plan (TEP). The IT&V team will set up and administer the requirements verification process (PVIS). The verification process also includes assembly and checkout activities associated with the system and segments (including International Participants), and end items. The IT&V team and the various IPTs will utilize appropriate personnel to ensure that integration and verification activities are satisfactorily completed. The IT&V team relationship with other elements of the verification community is depicted in Figure 4–2.

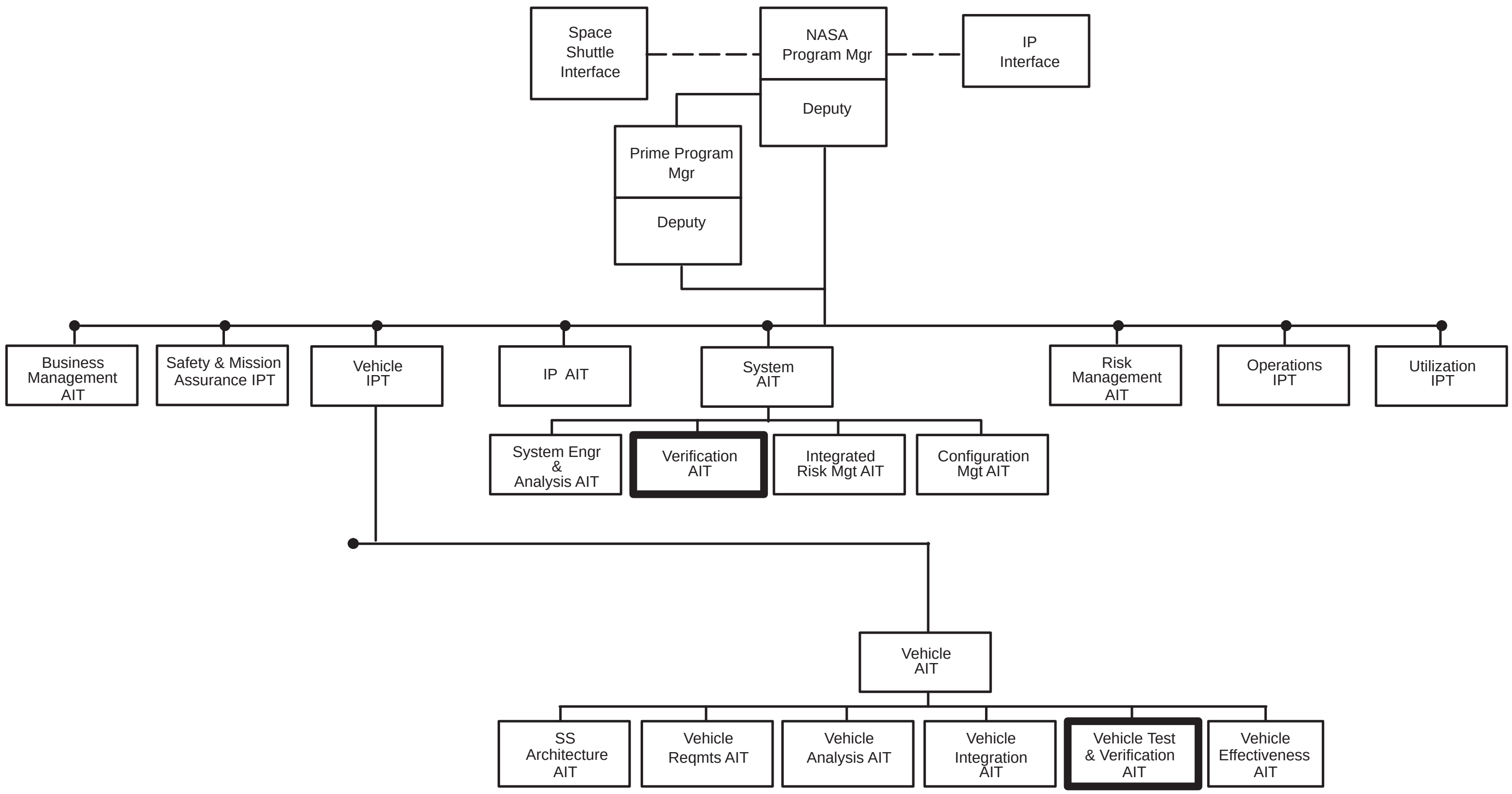


FIGURE 4–1 PRIME/NASA AIT/IPT STRUCTURE

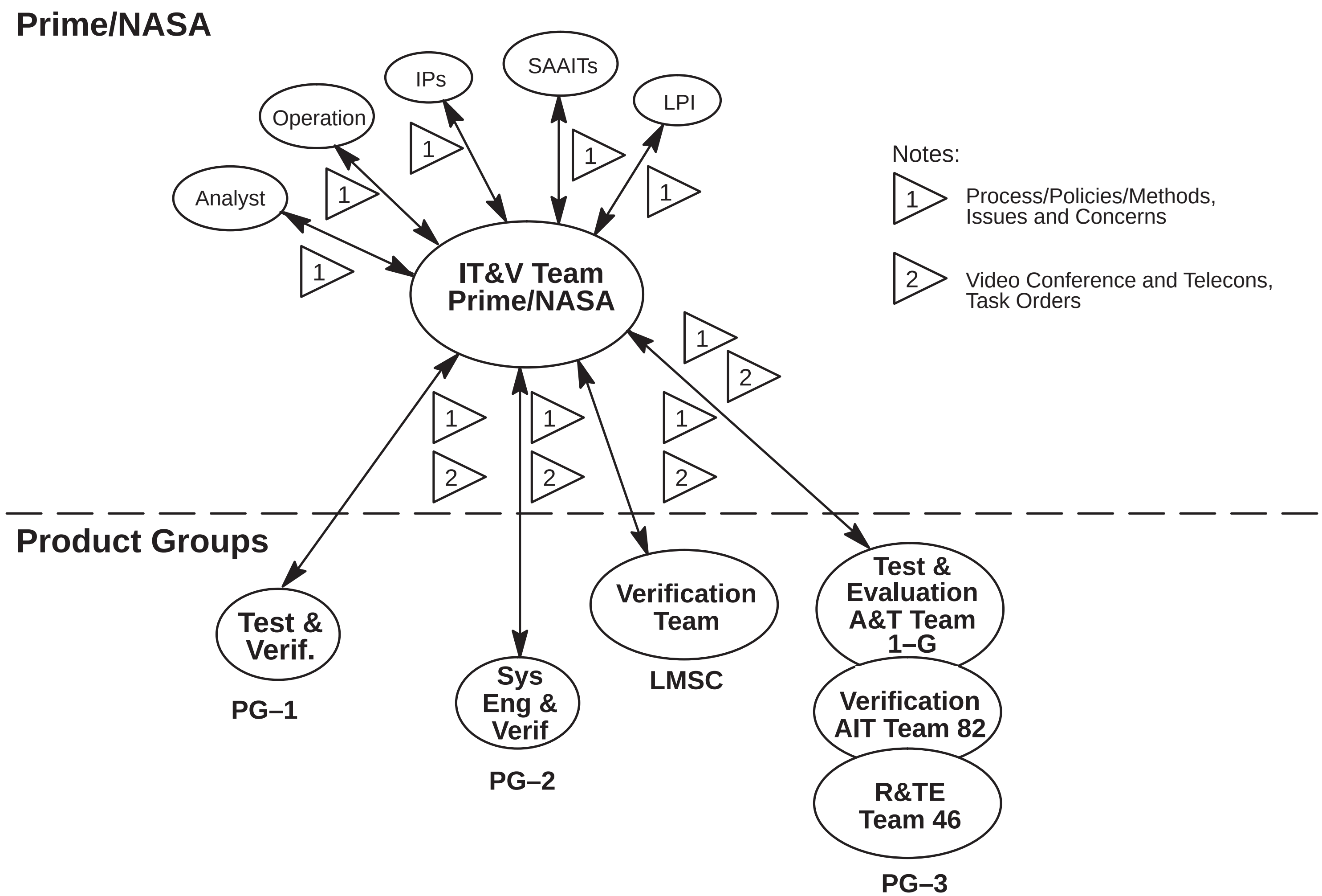


FIGURE 4–2 IT&V RELATIONSHIPS

4.2.2 NASA

4.2.2.1 NASA PROGRAM MANAGEMENT OFFICE (PMO)

NASA PMO has membership on the IT&V team. In addition to working on the combined NASA/Prime Contractor activities, NASA's role includes the verification of GFE items, coordination of Joint International Participant/U.S. verification activities, and provisioning of resources and facilities for test and verification related activities.

4.2.2.2 KENNEDY SPACE CENTER

NASA ISSA is responsible for hosting KSC launch processing activities through assembly of end items into launch packages. This will be done in accordance with procedures and test equipment provided by the Prime Contractor, Product Groups and/or IPs using KSC facilities. Launch processing is further discussed in section 9.0.

4.2.2.3 JOHNSON SPACE CENTER

The Missions Operations Directorate (MOD) and the NSTS Program Office at JSC in conjunction with the Prime Operations Team will implement on–orbit assembly and checkout of the ISSA. This includes preparation and validation of all required crew procedures. JSC also provides Facilities, GFE, and Services in support of the ISSA verification program. MOD is responsible for verifying USGS elements.

4.2.3 PRIME CONTRACTOR

The Prime Contractor is responsible for the verification of the ISSA System and the U.S. On–orbit segment and interfaces with the NSTS, IP segments, and USGS as depicted in Figure 1–1. The Prime will approve or concur with selected PG verification activities as part of the PG Verification Assessment Process.

4.2.3.1 PRODUCT GROUPS (PG)

The Product Groups providing end items receive verification technical direction from and are represented on the IT&V team. The Product Groups are responsible for providing verification processes, plans, and status on their end items and on–orbit replacement units. Selected verification activities will be approved or concurred with by the Prime. They will provide the verification planning and status data to the Prime Contractor in accordance with their respective Master Verification Plan(s). The PGs, as agents for the Prime Contractor are responsible for receiving and inspection, and post delivery checkout of their end items at KSC, to the point of handoff to KSC for Shuttle integration. PG support required by the Prime Contractor, other than receiving and inspection and post delivery checkout, will be addressed through PG SOWs Exhibit C.

4.2.3.2 LOCKHEED MISSILES AND SPACE COMPANY (LMSC)

LMSC is responsible for the procurement of the FGB from the Russian supplier, Khrunichev. LMSC will prepare the FGB procurement specification, and is responsible for the oversight and monitoring of the FGB verification program for the Prime. LMSC is responsible for assisting the Prime in the integration of the FGB into the ISSA program, including planning the verification of FGB performance and interfaces with the U.S. Segment and Russian Segment elements.

LMSC receives direction from and has membership on the IT&V team for verification activities.

4.2.3.3 PROGRAM FURNISHED MATERIAL (PFM)

PFM is material/equipment provided by the program that is considered a performance driver in the integrated performance of a delivered element, and is therefore controlled by a negotiated requirements document and interface document.

All PFM specifications, the compliance to, and traceability are the responsibility of the PFM developer. Essentially, both the End Item Developer and the PFM Developer must work together to ensure requirements are allocated correctly and are documented in the PFM Developer’s specification. The End Item Developer is responsible for ensuring their requirements, allocated to the PFM Provider, are linked in the Requirements and Traceability Management (RTM) system. The PFM Developer is responsible for providing PFM that has been verified to the end-item developer’s allocated requirements.

The PFM Developer is responsible for PFM specification compliance and close-out.

The End Item Developer’s end–item verification program must encompass verification activities which demonstrate that the allocated PFM requirements were met:

a. Functional performance/integrated testing and analysis must include PFM.

b. Design constraints and physical requirements will be verified by analysis, using the PFM ADP, and/or testing.

4.2.4 INTERNATIONAL PARTICIPANTS

Each International Participant will integrate and verify their end items in accordance with their segment specifications and agreed to IRDs and ICD Part 1s. They also will provide verification traceability and participate in joint verification activities as agreed to in the applicable BI&VP, and support assembly and checkout of their end items with the USOS.

4.2.5 GOVERNMENT FURNISHED MATERIAL/EQUIPMENT (GFM/GFE)

GFM (GFE) is material/equipment that has been purchased directly by the NASA/Government and is used by the Prime/PGs on the ISSA program.

Qualification of the GFM is the responsibility of NASA/Government and no additional verification on qualification of the GFM will be performed by the Prime/PGs. GFM specifications, traceability and compliance are the responsibility of the GFM developer. The Prime Contractor is responsible for ensuring requirements are allocated to the End Item Developer. The GFM Developer must assure to the Prime Contractor and the End Item Developer that their specifications include all the allocated requirements. The ISSA Program Office is responsible for entry and maintenance of the GFM specifications and traceability in the RTM system. The GFM Developer is responsible for providing GFM which has been verified to the End Item Developer's allocated requirements.

The End Item Developer's end-item verification program must encompass verification activities which demonstrate the allocated GFM requirements were met. Verification planning activities should identify:

a. Functional performance and integrated testing that uses GFM

b. Design constraints and physical requirements that are validated or verified using GFM

These agreements and definitions of responsibility will be documented in applicable Project Implementation Agreements (PIAs). Status will be provided to the ISSA program as defined in the PIA.

To ensure the ISSA verification philosophy described in this document is consistently applied across the program, new GFE development will meet the intent of the "Five-Step Verification Process". Implementation of the verification approach used for new GFE will be approved by the NASA/Prime IT&V Team.

4.3 VERIFICATION PROCESSES

Processes used by the IT&V team consist of both ISSA program processes and verification unique processes. Program management processes are described in detail in the ISSA Program Execution Plan, D684-10044-1, section 4.0

4.3.1 PROGRAM PROCESSES

The IT&V team will support and comply with ISSA program processes. The IT&V team will also support program reviews. Program processes and reviews are described in detail in the Program Execution Plan, D684-10044-1. They are also briefly mentioned in Tables 4-I and 4-II, to identify the IT&V team's role and involvement.

Table 4–I briefly describes the program processes in which the IT&V team is involved.

TABLE 4–I PROGRAM PROCESSES SUPPORTED BY VERIFICATION

Program Process/Implementing Doc	Verification Role
Program Media (D684-10002-1)	Comply with program media process and procedures in handling IT&V team products, data and information.
Cost Management	Comply with integrated cost management process for establishing and managing Verification life-cycle costs.
Configuration Management (D684-10097-1) (SSP 41170) (SSP 50123)	Comply with CM AIT requirements and policies for baseline establishment and change management. Support FCA.
Schedule Planning (D684-10086-1)	Comply with the integrated schedule planning process, to plan and manage IT&V team schedules.
Risk Management (D684-10054-1)	Support integrated risk management process thru identification assessment, and abatement of verification risks.
Program Reviews	Provide verification products, data and information in support of program reviews, including identification and disposition. See Table 4–II for summary.
Management Emphasis System	Use MES approach, and system as desired, to identify, categorize and resolve verification issues/concerns.
Metrics (D684-10057-1)	Identify, collect and act on verification metrics data identified in the IT&V AIT TEP.
Certificate of Flight Readiness (SSP 50108)	Provides traceability reports and verification completion notices, as inputs to the CoFR process, to satisfy CoFR criteria.
Quality Assurance (D684-10097-1) (SSP 41173)	Support PCAs (1st article only) and Acceptance Reviews with Traceability and Verification closure data (Inputs to Acceptance Data Packages.)

Table 4–II briefly describes the program reviews in which the IT&V team is involved.

TABLE 4–II IT&V PROGRAM REVIEW PARTICIPATION SUMMARY

Review	Objectives	Supporting Verification Documents
SRR	Establish Program functional baseline.	MG05 draft submittal.
SDR	Define system characteristics and identify configuration items.	MG05, initial release of the and VE24 Traceability Reports VE24 Compliance Reports for the System, USOS, and USGS Segment Specification. (End Item Oriented) Test Procedures, Test Reports, VE24 Compliance Reports, and VE20 Detailed Verification Requirements.

TABLE 4–II IT&V PROGRAM REVIEW PARTICIPATION SUMMARY – Continued

Review	Objectives	Supporting Verification Documents
CDR	Certifies the adequacy of each CI detailed design for meeting performance and development requirements of the CI development spec. prior to beginning fabrication. Interface requirements will also be considered.	Integration and Verification Implementation Plan PG Master Verification Plans.
DCR/FCA	Certifies the adequacy of each CI detailed design for meeting performance and development requirements of the CI development spec. prior to beginning fabrication. Interface requirements will also be considered.	VE20 Detailed Verification Requirements (initial submission), and VE24 Traceability Reports.
IDR	Evaluates the progress, technical adequacy, and risk resolution of the selected design approach.	VE20 Detailed Verification Requirements (initial submission), and VE24 Traceability Reports Integration & Verification Implementation Plan.
AR/PCA	Certifies the hardware and software have been designed with no defects. It formally establishes and documents the exact configuration of each item of HW and SW at the time of acceptance.	Inputs to the Acceptance Data Package.
ORR	Certifies that ground and flight support organizations are prepared to support a mission, that a launch package is prepared for installation into the Orbiter, and that the pending LP configuration is compatible with the on–orbit stage configuration.	Traceability report depicting satisfactory compliance with governing specifications.
FRR	Certifies that all appropriate organizations, IPs and associated contractors as well as the appropriate LP HW & SW, support facilities, and the on–orbit stage are prepared to support the subject launch.	

Notes: Data Requirement Numbers indicated where applicable.

4.3.2 VERIFICATION UNIQUE PROCESSES

The IT&V team has established groundrules and processes to structure its work performance.

Certain criteria for some of these unique processes are highlighted below. These are described in more detail in section 7.0 of the IT&V AIT TEP.

4.3.2.1 COMMUNICATIONS

Because the IT&V team is not colocated, a weekly joint video conference and telecons to review team activities will be held. This conference will include the IT&V team leaders and the team representatives located at the Product Groups' facilities. The conference will be used to identify issues and concerns and to assign action teams to resolve them. The material from this meeting will be used to provide inputs to the Vehicle AIT/IPTs and the SAIT/IPTs. In addition, on–site T&V working groups will be held with PGs individually and collectively per Prime Contractor schedules. Communication paths are as shown on Figure 4–2.

4.3.2.2 PROCESS SAMPLING/ASSESSMENT

To ensure the verification processes of the PG subcontractors, GFE providers and IPs conform to applicable program standards and directions, a selected sampling of verification processes (as well as verification products and data, when necessary) will be reviewed and/or assessed.

4.3.2.2.1 VERIFICATION ASSESSMENT OF PRODUCT GROUPS

Verification assessments will be conducted on selected PG verification activities to ensure physical, functional, and operational compatibility of Product Group components and their interfaces with other ISSA components. The focus will be on conformance with the verification approach specified in the PMI&VP and the PG Master Verification Plans.

Verification assessment will be established by the IT&V group with inputs from the PGs and other program level organizations. The criteria for selection will include safety and performance critical areas, particularly those associated with interfaces with components which are not the responsibility of the specific PG. This selection will be documented in the I&VIP.

Periodic visits by personnel representing the IT&V team will be made to each PG to accomplish the assessment. Prior to the visit, pre–coordination with the PG will establish the agenda for the activity. It will include a number of end item or distributed system verification processes. Concentration will be on the execution of verification activities, including observance of specific tests, inspection processes, and/or verification demonstration activities, as well as discussion of analysis results.

The results of each verification assessment visit will be recorded by the IT&V personnel in a report documenting the adherence of each PG to the established verification processes, reflecting the status of selected verification activities, and providing recommendations for changes that will result in a comprehensive ISSA verification program.

4.3.2.2.2 PROCESS SAMPLING OF INTERNATIONAL PARTNERS

Process sampling is the review, by NASA and/or its Prime Contractor, of selected International Participant verification activities or processes that show that the International Participant’s design meets its allocated requirements. The activities reviewed, as a minimum, will be those that confirm that the safety, performance, and interfaces of the IP element have been verified. Process sampling may require that a meets-or-exceeds assessment has been completed to confirm that the International Participant’s specifications and standards are acceptable to the ISSA. For process sampling, NASA or the Prime will witness/monitor verification activities, review requirements traceability, and perform assessments to ensure that the documented process was followed. Process sampling is not a technical review by NASA or the Prime of the correctness or completeness of the verification data. NASA and the International Participant will jointly develop a schedule for process sampling giving the dates and data to be used in this process.

The IT&V team will write a report addressing the results of the process sampling. Some of these activities will be observed by technical experts from the Prime and/or NASA who will perform quick look assessments of the results of the IP verification activity. Quick Look Reports will be written that summarize the results of the process sampling activities (see paragraph 4.4.3.8 for a description of this report).

Process sampling activities, in general, will be agreed to in the applicable IP BI&VP and defined in detail in the I&VIP. Data (estimated plans, procedures, reports, etc.) identified in the I&VIP as needed to support process sampling will be added to the appropriate IP data exchange list.

4.3.2.2.3 GOVERNMENT FURNISHED EQUIPMENT VERIFICATION ASSESSMENT

Verification assessment of GFE that is being developed for the ISSA program will be accomplished similar to the way it is done for the PGs.

4.3.2.3 TECHNICAL TASK AGREEMENTS (TTAs)/PROJECT IMPLEMENTATION AGREEMENTS (PIAs)

Technical Task Agreements/Project Implementation Agreements are used to identify and authorize a portion of the ISSA work, including verification effort, that is required by the responsible Prime/NASA program AIT/IPTs and that is best filled by a NASA institution. TTAs are negotiated by the AIT/IPTs with NASA center institutions to accomplish specific tasks, which include providing GFE, accomplishing specific tasks producing products required by the Product Groups or Prime, and providing specific Institutional expertise to an AIT/IPT. A constraint is that the projected costs and civil servant personnel are to be within each fiscal year's budget for the applicable TTAs and within the allocation established for each AIT/IPT.

Since the TTAs are subject to annual fiscal year budget allocations, these TTAs must be updated each year to reflect budget constraints as well as to specifically consider desirable changes to the current activities. Consequently TTAs must be generated and approved for the beginning of each fiscal year. Changes are incorporated after appropriate approval during the year, with a special review of them planned in the middle of the fiscal year.

Each AIT/IPT coordinates with the appropriate NASA institution to generate the applicable new or modified TTAs. In addition each AIT/IPT (architecture, subsystem, analysis, launch package, etc.) coordinates with the Integrated Test and Verification Team on each TTA involving tasks that execute a detailed verification objective to assure that the TTA is necessary and will support satisfaction of verification requirements. The Integrated Test and Verification team will support the test planning, test readiness reviews, test conduct, and documentation activities.

In addition to the TTAs which authorize specific tasks, GFE PIAs are required for developed or modified GFE delivered from U.S. sources, through the Program Office, to the ISSA Prime Contractor/Product Groups. These bi-directional “Project Commitment Contracts” quantify the reciprocal understandings the GFE providers have with the ISSA Program Office and its Prime Contractor. Each PIA defines all pertinent development and/or integration activities and deliverables that the NASA institution provides to its GFE customer.

4.3.2.4 STRUCTURES AND MECHANISMS TEST PLANNING CONCURRENCE PROCESS

Per Structural Design and Verification requirements (SSP 30559) and Payload Verification requirements (NSTS 14046), Structures and Mechanisms (S&M) test planning data will be submitted to the VAIT for recommendations and/or approval. Figure 4–3 details the submittal process for the PGs to the Prime. All appropriate S&M data required to satisfy SSP 30559 and NSTS 14046 data requirements will be provided by Prime data requests or through the Data Accession List. The submittal of S&M test planning data will be supplied to the VAIT through the Prime Data Management Organization. If coordination with the shuttle program is required, the VAIT will submit the appropriate documentation to the shuttle program.

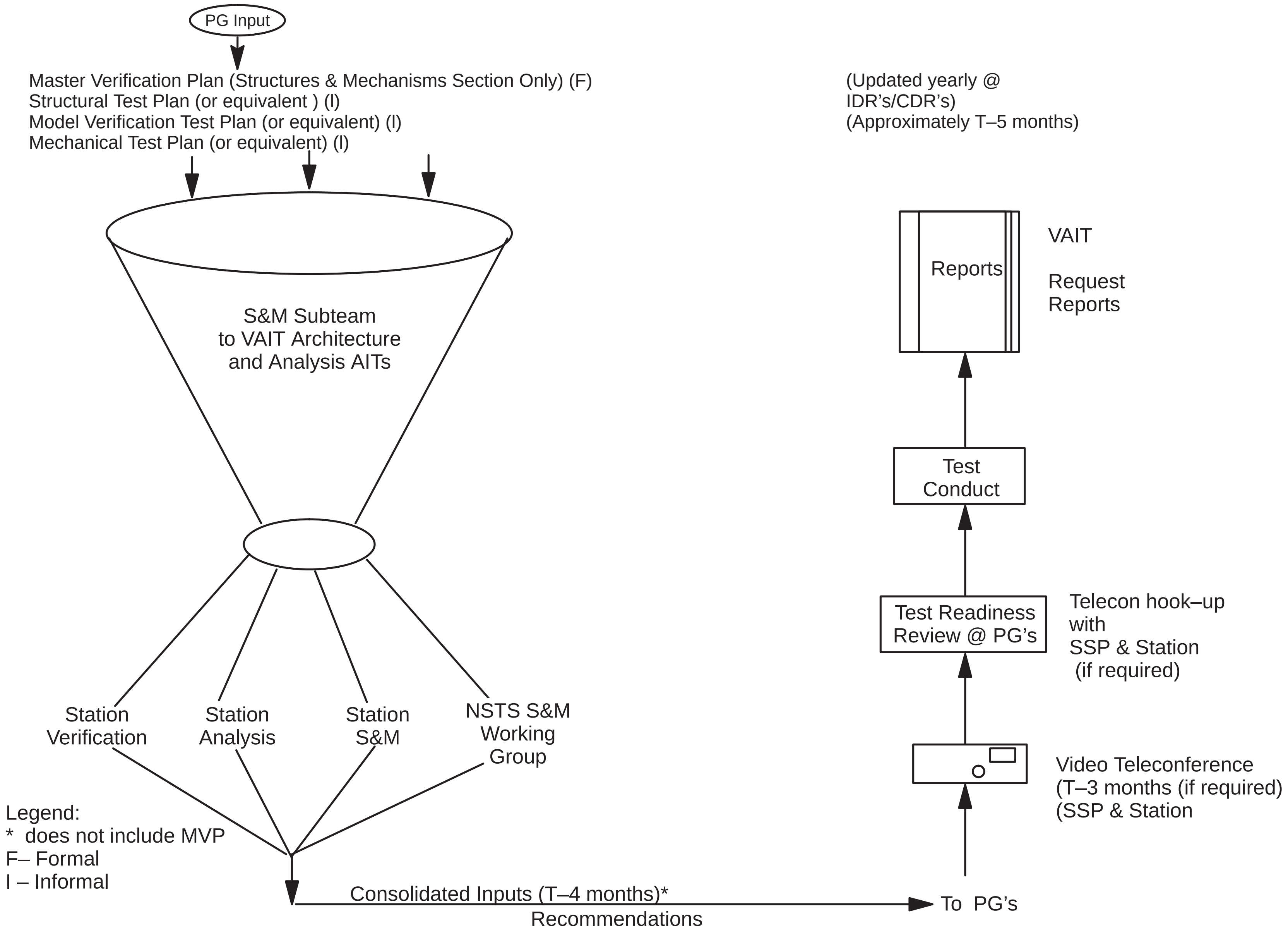


FIGURE 4–3 STRUCTURES & MECHANISM DOCUMENTATION CONCURRENCE PROCESS

4.3.2.5 PROGRAM VERIFICATION INFORMATION SYSTEM (PVIS) PROCESS

PVIS is a relational database that uses the Requirements and Traceability Management (RTM) software application to provide the ability to track and sort large amounts of changing data in ways which can provide managers with updated information on their respective project responsibilities. PVIS provides IPTs the ability to independently trace a requirement to its origin, input verification data into PVIS for requirements allocated to their IPT, assess requirement impacts, track corresponding verification status, and review any changes made to the requirements (requirement history). Figure 4–4 depicts the relationship of PVIS to the Five-step Verification Process. For more details on PVIS see paragraph 8.3 of this document or the PVIS process document D684-10021-1.

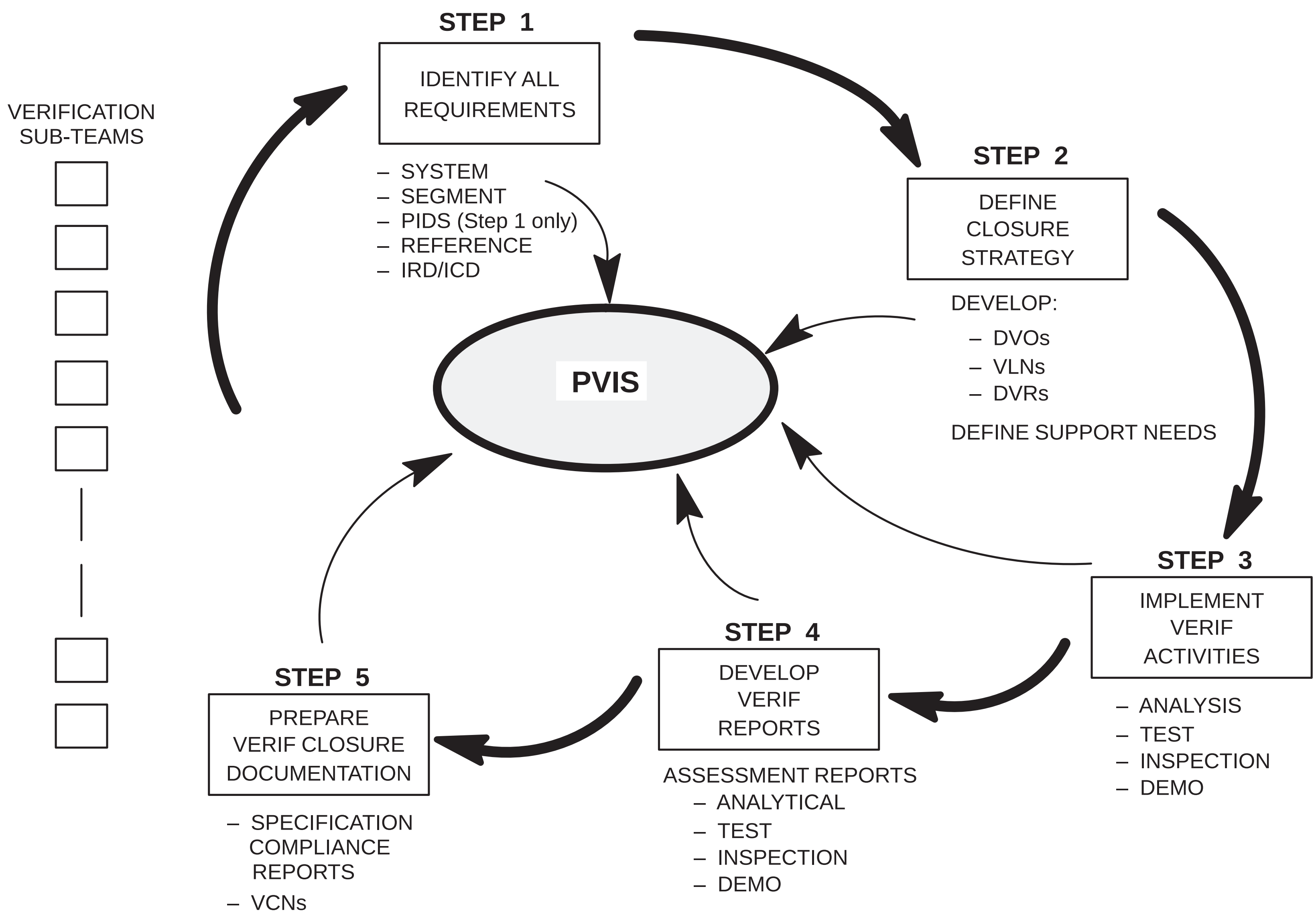


FIGURE 4–4 PVIS RELATIONSHIP TO THE FIVE-STEP PROCESS

4.4 VERIFICATION DOCUMENTATION PRODUCTS

This section addresses the documentation and data products that are required to manage the U.S. Verification Program activities as shown in Figure 1–1. This documentation consists of specification, plans, reports and PVIS data. The documentation and data products are discussed in the following paragraphs.

4.4.1 SPECIFICATIONS AND REQUIREMENTS

The ISSA Specification Tree is depicted in Figure 3–2. The documentation shown in that Figure includes U.S. and IP Specifications, IRD's and ICD Part 1s. Both the U.S. and International Participants participate in the development of verification requirements for international interface requirements. The IT&V team's responsibility for contributions delivery and maintenance of these documents. The top-level set of U.S., Joint and IP documentation which contains section 4.0 verification requirements are shown in Table 4–III.

TABLE 4–III SPECIFICATIONS

Name	Responsibility	Applicability
U.S. On–Orbit Segment Specification	U.S.	Prime
U.S. Prime Item Development Specification (PIDS)	U.S.	Prime/PGs
ISSA System Specification	U.S./IPs	Prime
IP Segment Specification	IPs	N/A
IP Interface Requirements Documents (IRDs)	U.S./ESA and NASDA	Prime
IP Interface Control Documents (ICDs) Part 1s	U.S./RSA	Prime
FGB Specification	U.S.	Prime/LMSC

The FGB Specification traces to the RSA Segment Specification and is used to procure the FGB for the U.S.

U.S. verification requirements feed the verification implementation activities of both the U.S. Prime and PGs. These activities are described in detail in the IV&IP.

Within these documents, the U.S. and International Participants may designate specific requirements as candidates for "joint" verification. Joint verification requirements between NASA–TO–ASI, or NASA–to–CSA are identified in section 4 of their respective segment specification. Joint verification requirements for NASA–to–ESA, NASA–to–NASDA, or NASA–to–RSA are identified in section 4 of their applicable IRDs or ICD Part 1s as shown in Table 4–III. Joint verification will be identified in the ISSA System Specification for the verification of segment–to–segment interfaces.

All joint verification activities feed verification implementation activities of both the U.S. and the International Participants. These activities are described in detail in the respective U.S.–to–IP BI&VPs.

In addition to the specifications, stage unique requirements will be derived as part of the flight by flight review process. Inputs to this process include the Integrated Operations Scenarios

(IOSs) and Operational Sequence Diagrams (OSDs). The requirements are defined in the AIRDs because they are required to support the incremental assembly of the Space Station on-orbit. These stage-unique requirements will be allocated to the appropriate specifications (end item, segment, system) via the change process and verified using the standard verification process as defined in sections 5, 6 and 7.

4.4.2 VERIFICATION PLANS

Verification program plans are published as both U.S. and bilateral documents. These program verification plans are developed to ensure that verification processes and approaches between the U.S., IPs and PGs are compatible, and that the sum of the individual verification effort will close ISSA program requirements. These are listed and described in Table 4–IV.

TABLE 4–IV VERIFICATION PLANS

Availability/ DR #	Name	Developed by	Recipient
SSP 50033	NASA/CSA Bilateral Integration & Verification Plan (BI&VP)	NASA/CSA Jointly	NASA/CSA and Prime
SSP 50034	NASA/ESA BI&VP	NASA/ESA Jointly	NASA/ESA and Prime
SSP 50102	NASA/ASI BI&VP	NASA/ASI Jointly	NASA/ASI and Prime
SSP 50035	NASA/NASDA BI&VP	NASA/NASDA Jointly	NASA/NASDA and-Prime
SSP 50101	NASA/RSA BI&VP	NASA/RSA Jointly	NASA/RSA and Prime
MG05	Program Master Integration & Verification Plan	Prime Contractor	NASA
DAL	Integration & Verification Implementation Plan	Prime Contractor	N/A
SS–VE–014	Product Group Master Verification Plan	Product Groups	Prime Contractor
EN05	Khrunichev Test and Verification Plan	KhSC/LMSC	LMSC/Prime
FGB02	FGB Verification Plan	Prime Contractor/ LMSC	NASA
As Assigned When Authorized	NSTS and ISSA/Prime Joint Verification Plan	NSTS and ISSA/ Prime Jointly	NSTS and ISSA/ Prime
As Assigned When Authorized	NASA MOD/USGS and NASA PMO/Prime Joint Verification Plan	NASA MOD/USGS and NASA PMO/ Prime Jointly	NASA MOD and NASA PMO/Prime

4.4.2.1 DR MG05 PROGRAM MASTER INTEGRATION AND VERIFICATION PLAN (PMI&VP)

The Program Master Integration and Verification Plan is the top level NASA/Prime ISSA document that establishes the verification philosophy, approach, and processes to be used by all program organizations. This includes definition of the interrelationships with the International

Participants. It defines roles and responsibilities of each participant, and establishes the method to be used to ensure specification compliance planning, traceability, statusing, and control.

4.4.2.2 BILATERAL INTEGRATION AND VERIFICATION PLANS (BI&VPs)

The BI&VPs are high-level international planning documents that describe the processes, exchanged products, activities and resources negotiated and agreed–to between the U.S. and the respective International Participants.

U.S.–to–International Participant verification schedules are negotiated by the verification team, and are published in the Bilateral Hardware and Software Exchange Agreements, Lists and Schedules document.

The individual and joint activities performed by international participants, to support U.S.–to–IP interface verification processes, are described in the BI&VPs.

Joint test plans, and joint test procedures will be prepared below the BI&VPs, to document lower–level joint verification details. U.S.–to–IP verification activities will be identified in the I&VIP (matrix) and implemented via detailed, joint implementation documentation as shown on Figure 3–3. These activities will be authorized by task order from the Prime or ECP.

International Participants develop their own MVPs.

4.4.2.3 INTEGRATION & VERIFICATION IMPLEMENTATION PLAN FOR ISSA SYSTEM AND U.S. SEGMENTS (I&VIP)

The I&VIP for ISSA System and U.S. Segments documents the Prime Contractor's verification and stage integration planning. The plan defines the activities to be performed that verify and close out requirements contained in the ISSA System and USOS Specifications. Flight Software and Data Load Verification and/or validation planning is also included. The plan implements the processes established in the PMI&VP. The I&VIP also allocates verification activities to two (2) groups of lower level planning – the PG MVPs and joint implementation plans. The inputs to the PG MVPs consists of enhancements/upgrades to the PG activities associated with specification compliance of their end-items. These enhancements upgrades are derived from step 2 of the Prime's Five-step process. The other group of planning is the detailed plans that implement the joint verification activities with the IPs, NSTS and USGS as depicted on Figure 3–3.

4.4.2.4 NATIONAL SPACE TRANSPORTATION SYSTEM (NSTS) AND ISSA/PRIME JOINT VERIFICATION PLAN

This plan will be a high level plan that describes the resources and specification compliance activities negotiated and agreed-to between the ISSA/Prime and NSTS organizations, when authorized. These activities will be identified in the I&VIP (matrix) and implemented via detailed joint implementation documentation as shown on Figure 3–3. or documentation that NSTS uses for NSTS/Payload Integration and Verification.

4.4.2.5 NASA MOD/U.S. GROUND SEGMENT (USGS) AND NASA PMO/PRIME JOINT VERIFICATION PLAN

This plan will be a high level plan that describes the resources and specification compliance activities negotiated and agreed-to between NASA PMO/Prime and NASA MOD/USGS organizations, when authorized. These activities will be identified in the I&VIP (matrix) and implemented via detailed joint implementation documentation as shown on Figure 3–3.

4.4.2.6 SS–VE–014 PRODUCT GROUP MASTER VERIFICATION PLAN (MVP)

A Product Group MVP establishes and controls the total verification process for that Product Group. It documents the planning, policies, and organization necessary to define and execute the verification operations for the deliverable hardware and software.

The MVP contains end item level planning information for development, qualification and acceptance, support to the assembly and checkout phase, and supporting documentation.

Each MVP also implements the processes established in the PMI&VP.

4.4.2.7 FGB VERIFICATION PLAN

Lockheed will support the Prime in the preparation of the FGB Verification Plan, Prime DR #FGB02. Lockheed will deliver to the Prime the Khrunichev Test and Verification Plan, (EN05), which will be delivered to NASA as an appendix to FGB02. The body of FGB02 will include Lockheed inputs which define Lockheed’s specific tasks in the oversight of Khrunichev’s verification activities, and process sampling of a selected set of requirements that are mission critical and have an impact on the safety–of–flight, as a minimum.

4.4.2.8 JOINT IMPLEMENTATION PLANS

Joint Implementation Plans will be developed, as required, to define detailed planning information to perform a joint verification activity with the IPs, NSTS and USGS. These will be detailed test plans in most cases.

4.4.3 VERIFICATION REPORTS AND DATA

Verification reports and data are created for the collection, consolidation and publication of verification data. Reports and data are produced when information is needed for future verification reference, or for delivery to other ISSA teams to support their processes.

Some reports may be completed by other disciplines on the ISSA program. In such cases, the Verification team collects and provides the data for the reports to the appropriate discipline.

Both and U.S. and IPs will be responsible to produce deliverables that identify verification completion of their end items. Acceptance data packages support the DD250, as discussed in section 6 of this PMI&VP.

Throughout the program it will be necessary to deliver information (data) relative to the verification plans and activities at any given level of the program to the level above to ensure adequate management insight into those activities. The data provided will enable appropriate management action to be taken when necessary. Data Requirement (DRs) are identified in the Prime Contractor's SOW between the Prime Contractor and NASA. The Product Group's SOWs between the Prime Contractor, the Product Groups and LMSC define contractual data deliveries on Supplier Data Sheets (SDSs).

These DRs and SDSs cover data content, delivery schedules, formats and intended use information. Conversely, PG requirements for data from the Prime are contained in the Contractor Furnished Data List. In addition, products will be identified that are not deliverable to NASA or the Prime Contractor but are available upon request. These items will be documented on the applicable Data Accession List. A complete list of verification reports is shown in Table 4–V. A more detailed description of these reports is found in following paragraphs.

TABLE 4–V VERIFICATION REPORTS AND DATA

Availability/DR or SDS Number	Name	Developed by	Recipient
VE20	Integration & Verification Requirements Report	Prime Contractor	NASA
VE24	Specification Traceability and Compliance Report	Prime Contractor	NASA
SS–VE–024	Traceability and Compliance Reports	Product Groups/ LMSC	Prime Contractor
*	Verification Completion Notices	Product Groups	Prime Contractor
*	Verification Analysis and/or Inspection Reports, as applicable	Product Groups	Prime Contractor
*	Verification Test and Demonstration Reports	Product Groups	Prime Contractor
*	Structural Test Planning Data	Product Groups	Prime Contractor
*	On–Line Data	Prime Contractor or Product Group	NASA or Prime Contractor
**	Joint Implementation Reports	NASA/IP Jointly	NASA/IP and Prime
*	Related Verification Data Require-ments	PG and LMSC	Prime Contractor
*	Interface Verification Visibility Report	Prime and IPs	IPs or NASA
*	Quick Look Reports (IP)	Prime	NASA
*	Process Sampling Report (IP)	Prime	NASA
*	Verification Assessment Report (PGs & GFE) Prime)	Prime	NASA

* As Requested, via the Data Acquisition List
** As agreed, via U.S.– IP BI&VPs

4.4.3.1 DR VE20 INTEGRATION & VERIFICATION REQUIREMENTS FOR ISSA SYSTEM AND U.S. SEGMENTS (PRIME)

The Integration & Verification Requirements for ISSA system and U.S. Segments documents program verification requirements to qualify U.S. flight and ground segments. The document will be written by Stage, starting with the assembly. This will establish the full ISSA system and U.S. On–orbit Segment Specification development with associated ground systems. All ISSA system and USOS specification requirements will be addressed. The DR VE20 document will be generated as a formatted report from PVIS. This will allow requirements to be reported by End–Item, Stage, ISSA or capability.

4.4.3.2 DR VE24 SPECIFICATION TRACEABILITY AND COMPLIANCE REPORTS (PRIME)

Specification Traceability and Compliance Reports document the section 3 design requirements verification traceability flowdown from source to closure for the ISSA System and, U.S. On–orbit Segment specification. The DR VE24 document will be generated as a formatted report from PVIS. The traceability and compliance can be reported by end item stage, launch package, ISSA system or capability. The reports are used as a map to show requirements and traceability, and the documentation path for compliance to each of the requirements in the ISSA system and USOS specification.

4.4.3.3 SS–VE–024 TRACEABILITY AND COMPLIANCE REPORTS (PG)

Traceability and compliance reports will be made available electronically to the Prime Contractor on a regularly scheduled basis to document specification requirement parent–child relationships and to provide traceability to closure for the end item specifications. This allows the SS-VE-24 document to be generated as a formatted report from PVIS by the Prime.

4.4.3.4 VERIFICATION COMPLETION NOTICES

Verification Closure Notices (VCNs) or equivalents will be prepared by the Prime/Product Group and LMSC. These notices will document the completion of verification tasks for each item. This will support for acceptance of items at or above the Orbital Replacement Unit (ORU) level. This data will be available via PVIS or the Data Accession List from the PGs and LMSC and by requirement from the Prime.

4.4.3.5 VERIFICATION ANALYSIS AND INSPECTION REPORTS

Verification analysis reports will document the results of verification analyses performed per the verification requirements to show compliance with design requirements.

Most of the Product Group’s verification analysis reports will be prepared in the Product Group’s native format, and will be available to the Prime upon request via the Data Accession List (DAL). Specific verification analysis reports will be delivered to the Prime via DR VE-23.

The use of DR VE-23 is to provide NASA with the analysis information as part of the evidence that the vehicle and subsystems (including structures) have the capability to meet the intent of all applicable requirements. DR VE-23 is also used to ensure analytical models contain the proper structure and content, and to aid in the evaluation of model designs.

DR VE-23 analysis reports will document all input data, assumptions and boundary conditions, analysis methodology, and analysis results needed to:

a. Demonstrate the proper design of the vehicle or subsystem in consideration of all design constraints. This includes analysis of vehicle performance and the performance of integrated subsystems with or without the effects of the Shuttle Orbiter and other orbiting vehicles.

b. Demonstrate that the vehicle or subsystem capabilities meet specific requirements. This includes analyses performed as part of the formal verification program.

Results of specification section 4 verification inspections will either be documented in Inspection Reports, or contained in an approved Quality Assurance or drawing release system. Non-compliance will be handled per established quality assurance provisions.

4.4.3.6 VERIFICATION TEST AND DEMONSTRATION REPORTS

These reports document results of tests and demonstrations performed per the verification requirements to show hardware and software compliance with design requirements.

The Verification Test and Demonstration Report will contain the applicable verification requirements correlated with the source of the requirement (i.e., the applicable specification requirement). The report will summarize verification results and be prepared in a manner that relates each reported item to each requirement. This data will be available via the Data Accession List.

4.4.3.7 LMSC SPECIFICATION TRACEABILITY AND COMPLIANCE REPORT

LMSC will prepare traceability and compliance reports that trace each FGB specification requirement to closure. This data will be supplied to Lockheed by Khrunichev, and will be entered into the PVIS database by Lockheed. The deliverable reports will be generated from the PVIS database.

4.4.3.8 QUICK LOOK REPORTS

These reports are an initial summary assessment of the process sampling activity described in paragraph 4.3.2.2.2 and planned in the I&VIP. These reports will not be used to determine whether the IP passed their test or met requirements but is meant to provide an early assessment of overall program compliance.

4.4.3.9 PROCESS SAMPLING REPORTS

These reports are written by the IT&V team as a result of an IP process sampling activity as discussed in paragraph 4.3.2.2.2. This is a more in-depth, detailed report than the Quick Look report (paragraph 4.4.3.8) and covers all the activities detailed in the I&VIP for each report.

4.4.3.10 VERIFICATION ASSESSMENT REPORTS

These reports are written by the IT&V Team as a result of a PG or GFE verification assessment activity as discussed in paragraphs 4.3.2.2.1 and 4.3.2.2.3 respectively and as planned in the I&VIP.

4.4.3.11 JOINT VERIFICATION REPORTS

A joint verification report will be generated for each of the joint verification activities performed with the IPs, NSTS and USGS. These reports will document the results of the activity performed and compare the results with the requirements.

4.4.3.12 INTERFACE VERIFICATION VISIBILITY REPORT (IVVR)

The IVVR format for NASA is similar to a verification matrix. Each section 3 IRD/ICD Part 1 requirement identified as Individual Verification responsibility for NASA will show a verification method in NASA's IVVR. Non-applicable entries in NASA's IVVR should correspond to section 3 IRD/ICD Part 1 requirements that were shown as not applicable to NASA.

For each applicable specification section 3.0 requirement in the IVVR, a verification requirement statement will also be developed and included following the matrix. The individual verification requirements statement will include the verification Method, Conditions, and Success Criteria.

The IVVR also contains a Specification Reference column. This column references the document number and paragraph of the corresponding segment, end–item or component level verification activity that will close the section 3 IRD/ICD Part 1 requirement.

Figure 4–5 shows the U.S. process flow for the collection of data, generation of the IVVR, and NASA customer delivery. See section 5.4.1.2 for further IVVR details.

The production of the IVVR will require the participation of the IRD Team, the Specification Team and the IT&V Team. Verification data will be uploaded from IRDs and ICDs to the PVIS. The format of the IVVR from each partner varies. These formats and the frequency of the exchanges between U.S. and IPs are documented in the BI&VPs and reflected in the individual U.S./IP data exchange list.

4.4.3.13 OTHER VERIFICATION DRs

Other applicable verification DRs are:

a. SS-VE-056B EMC Test Plan/Procedure/Report

The EMC Test Plan/Procedure/Report shall describe the plans/procedures to be used in EMC testing of deliverable end items, subsystems and systems. The EMC Plans, Procedures and Reports will be used for the management of the characteristics (compatibility, bonding, grounding) of electrical, electronic, and electromechanical deliverable end item.

b. SS-VE-059B EME Test Plan/Procedure/Report

The EME Test Plan, Procedure, and Report will ensure that the hardware provider’s design is self-compatible, has accommodated EME design requirements, and is compatible with the environment and interfacing hardware.

c. SS-VE-058A EME Analysis Report

EME Design Analysis Report shall provide analysis which supports compatible integration of the Product Group’s hardware.

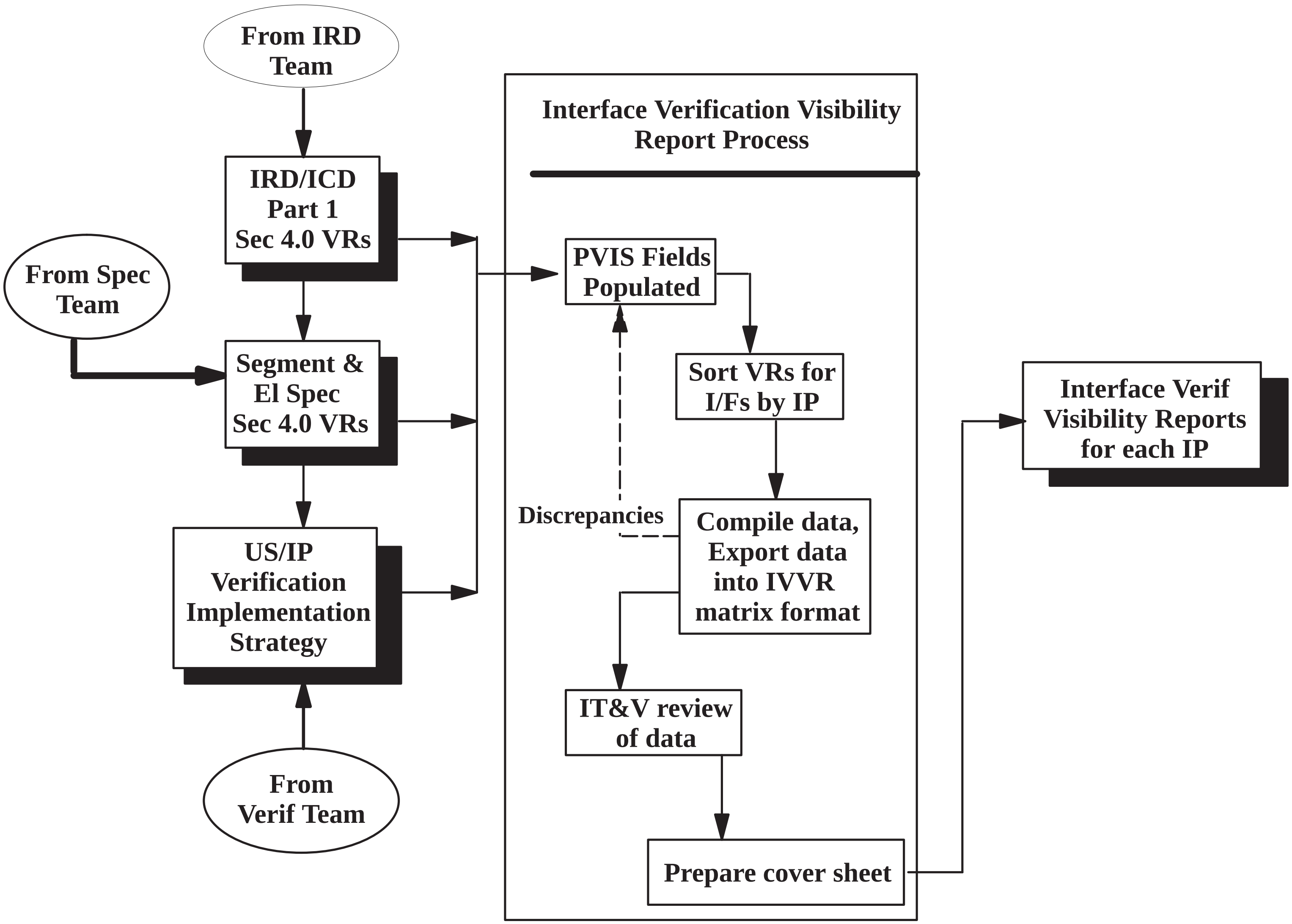


FIGURE 4–5 IVVR DEVELOPMENT AND PUBLICATION PROCESS

5.0 VERIFICATION PLANNING

The overall objective of verification is to ensure the ISSA complies with all specified requirements. Verification planning is used to clearly delineate a strategy to satisfy each ISSA System and USOS Specification requirement, as well as the applicable IRD and ICD Part 1 requirements. Planning will define how each requirement will be verified, and which of the four verification methods; test; demonstration; analysis; or, inspection, or any combination of these methods, will be used. This planning is conducted during the Performance and Functional Requirements Compliance Phase, as depicted on Figure 3–1 and is implemented by Steps 1 and 2 as depicted in Figure 5–1, Five-step Verification Process.

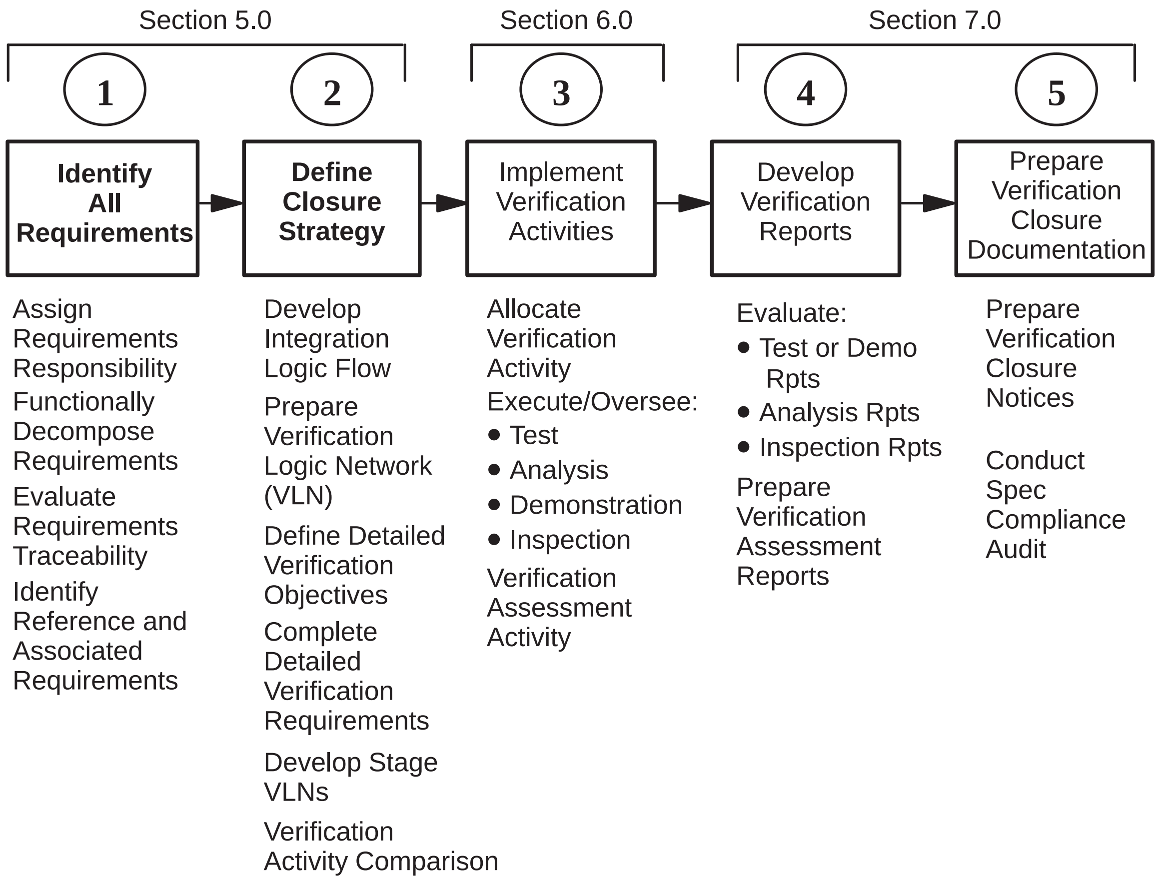


FIGURE 5–1 PRIME CONTRACTOR'S FIVE–STEP VERIFICATION PROCESS

Prime Contractor verification planning is accomplished in two distinct steps, i.e.: Step #1– Identification of Requirements; and, Step #2 – Define Closure Strategy. These steps are addressed in sections 5.1 and 5.2 respectively. The Product Group Contractor's approach to verification is in accordance with the intent of the Five-Step Process and is described in section 5.3. The Product Group Contractors are responsible for verifying their end items by the four methods described in sections 5.2.2.1–5.2.2.4.

The process for verification of hardware and software is the same, but the terminology employed in the software process is different. For a further description of the Software verification process, see the Software Development Plan (SDP), D684-10017-1.

5.1 VERIFICATION REQUIREMENTS IDENTIFICATION (STEP #1)

Each requirement must be assessed to ensure that it is verifiable. To accomplish this, each requirement identified in an applicable specification, must be assessed in the order shown below, before proceeding to Step #2.

a. Assigned to a verification subteam for ownership

b. Functionally decomposed to lower level requirements

c. Traceable to the lowest level of implementation

d. Evaluated to identify associated and reference requirements

In general, requirements are identified in: IRDs (ESA and NASDA only), ICD Part 1s (RSA only), ISSA System, USOS, USGS, PID Specifications, IP Specifications, and reference documents.

PIDs are used during Step 1 only to ensure that requirements are flowed down and up correctly and are linked properly.

5.1.1 ASSIGNMENT OF REQUIREMENT OWNERSHIP TO VERIFICATION SUBTEAMS

Each ISSA System and USOS Specification requirement, as well as the related IRD and ICD Part 1 requirements, are to be specifically assigned to a responsible IPT for strategy development and execution. The IT&V AIT will work with each subsystem IPT and technical discipline IPT to determine the correct ownership of ISSA System Specification requirements. Since it logically follows that each ISSA System Specification requirement can be traced to lower level specifications, verification subteam ownership assignment can be made at the ISSA System Specification level. Initial ownership is assigned by a matrix, found in the IT&V Team Execution Plan (TEP) which establishes primary verification responsibility for each specification requirement.

Secondary verification responsibility is determined by verification subteam planning activities. For each requirement, secondary ownership may include one or multiple subteams. (See section 5.2.2, prepare VLN.)

5.1.2 FUNCTIONAL DECOMPOSITION OF REQUIREMENTS

After requirements are assigned ownership, specification traceability is compared against the existing functional decomposition to determine the lowest applicable and verifiable level. This ensures all applicable requirements have been identified to bound the scope of the verification activities. This is accomplished by extracting pertinent data from the ISSA Functional Decomposition Document (D684–10200–1) and comparing this requirement decomposition against the requirements traceability (discussed in section 5.1.3). These sub-steps, conducted by the verification subteams, validate that the requirements are in place to begin the process and identifies discrepancies. The level of functional decomposition is illustrated against specification requirement flowdown in Figure 5–2, Functional Decomposition versus Specification Requirement Allocation to the End Item level only.

5.1.3 REQUIREMENTS TRACEABILITY

Specification section 3 requirements traceability/allocation is established for the ISSA specifications as shown in Figure 5–3. Higher–level to lower–level requirement traceability is evaluated and documented during Step #1 of the Five–Step Process to ensure 100% requirement allocation to the level of verification implementation.

The Prime Contractor's verification traceability process for specification section 4 requirements is shown in Figure 5–4. The Prime Contractor is responsible for establishing and maintaining the traceability of requirements in the ISSA System and the USOS specifications through the verification traceability process to the closure documentation.

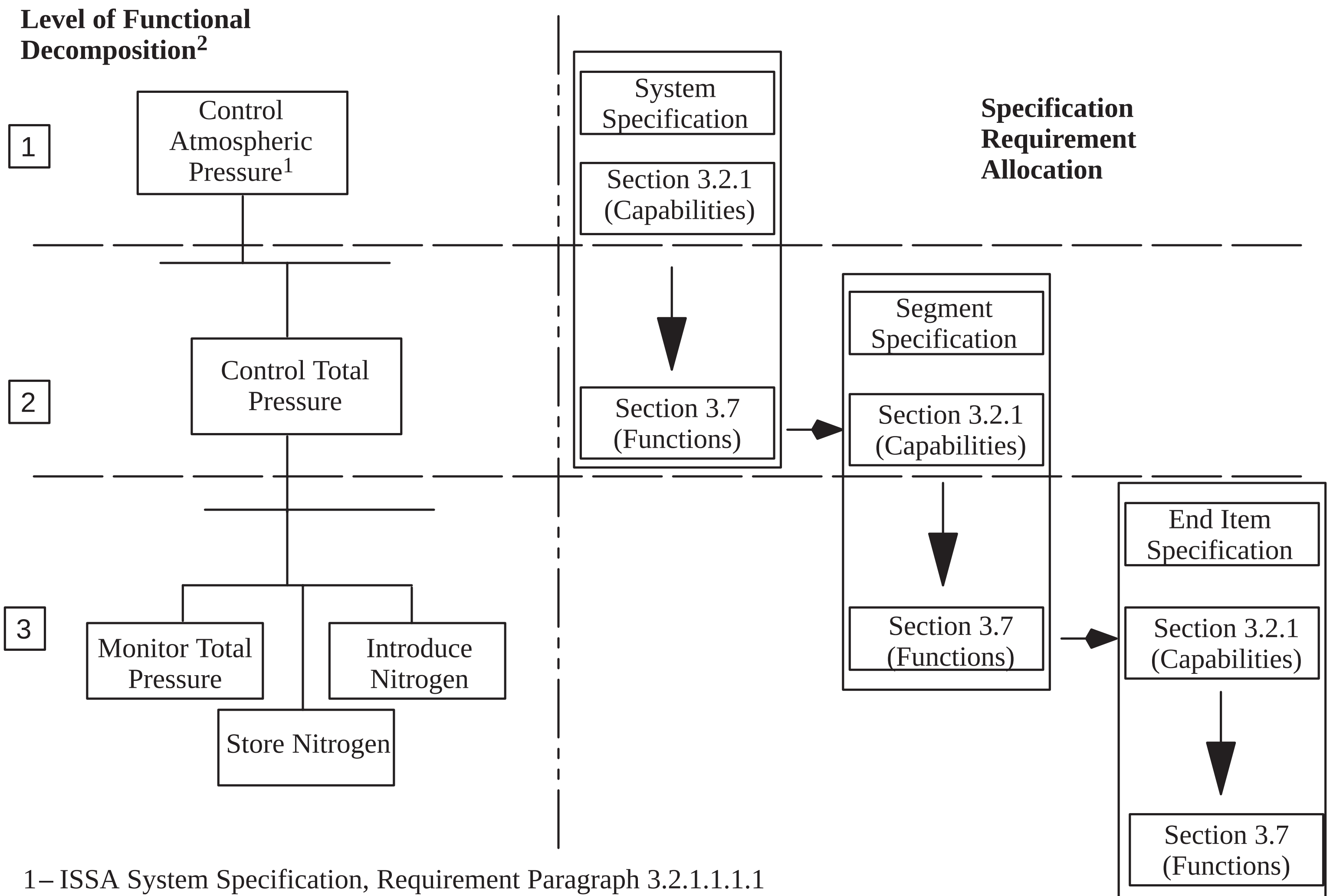
The Prime Contractor's PVIS database captures and maintains the requirements and associated verification traceability data, and provides the required configuration control. The Prime Contractor will establish and maintain upward traceability of requirements in the PVIS database from:

a. The U.S. Prime Item Development Specifications to the USOS Specification upward to the ISSA System Specification

b. The USGS specification to the ISSA System specification

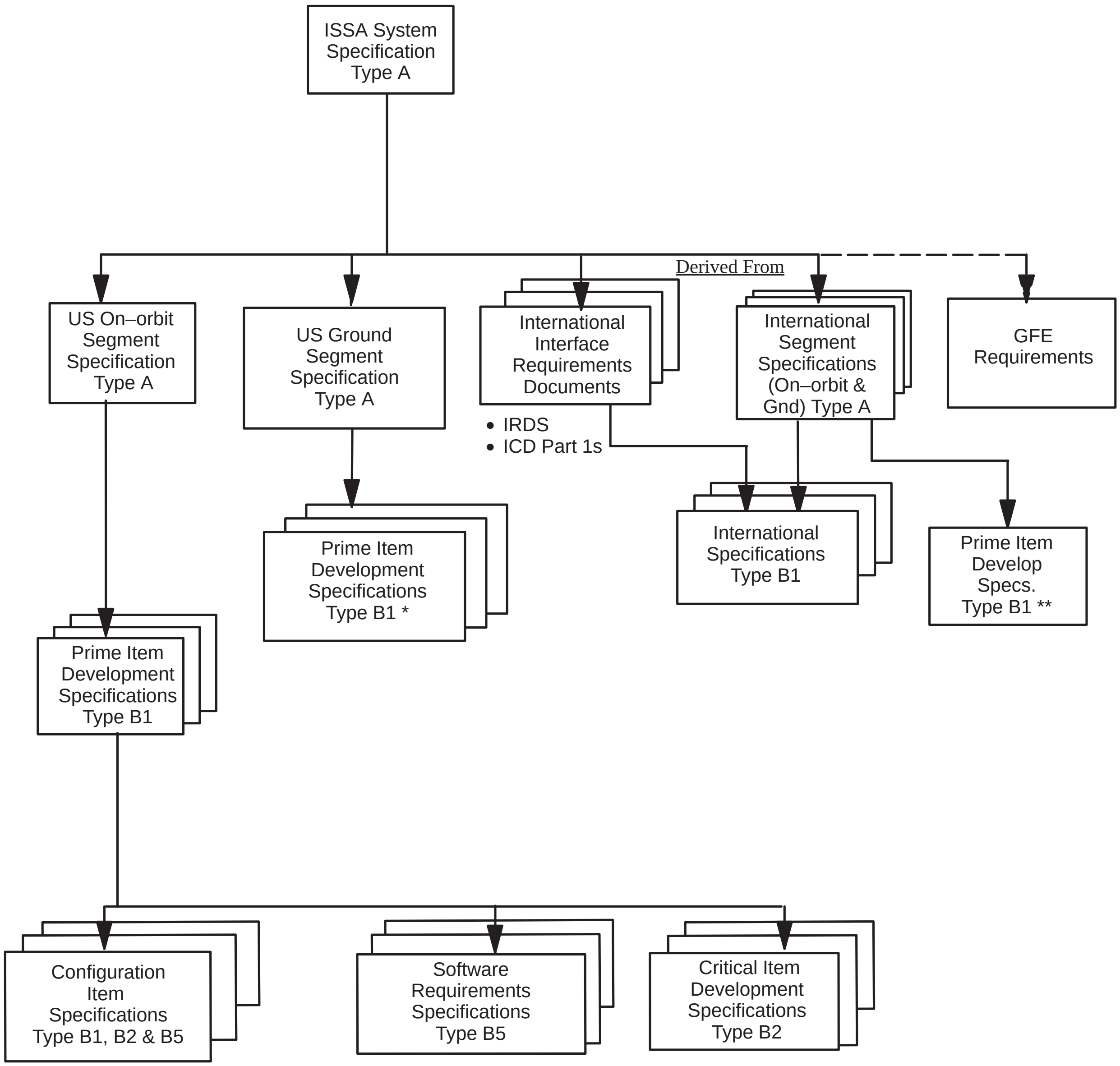
c. The International Participant Segment specifications and International IRDs and ICD Part 1s to the ISSA System specification

d. The FGB Specification to the Russia Segment Specification



1 – ISSA System Specification, Requirement Paragraph 3.2.1.1.1.1
2 – Functional Decomposition Document (D684–10200–1, Revision A)

FIGURE 5–2 PRIME FUNCTIONAL DECOMPOSITION VERSUS SPECIFICATION REQUIREMENT ALLOCATION



Notes:
* • MBF for Prime Contractor
** • FGB for Prime Contractor

FIGURE 5–3 REQUIREMENTS TRACEABILITY/ALLOCATION PROCESS

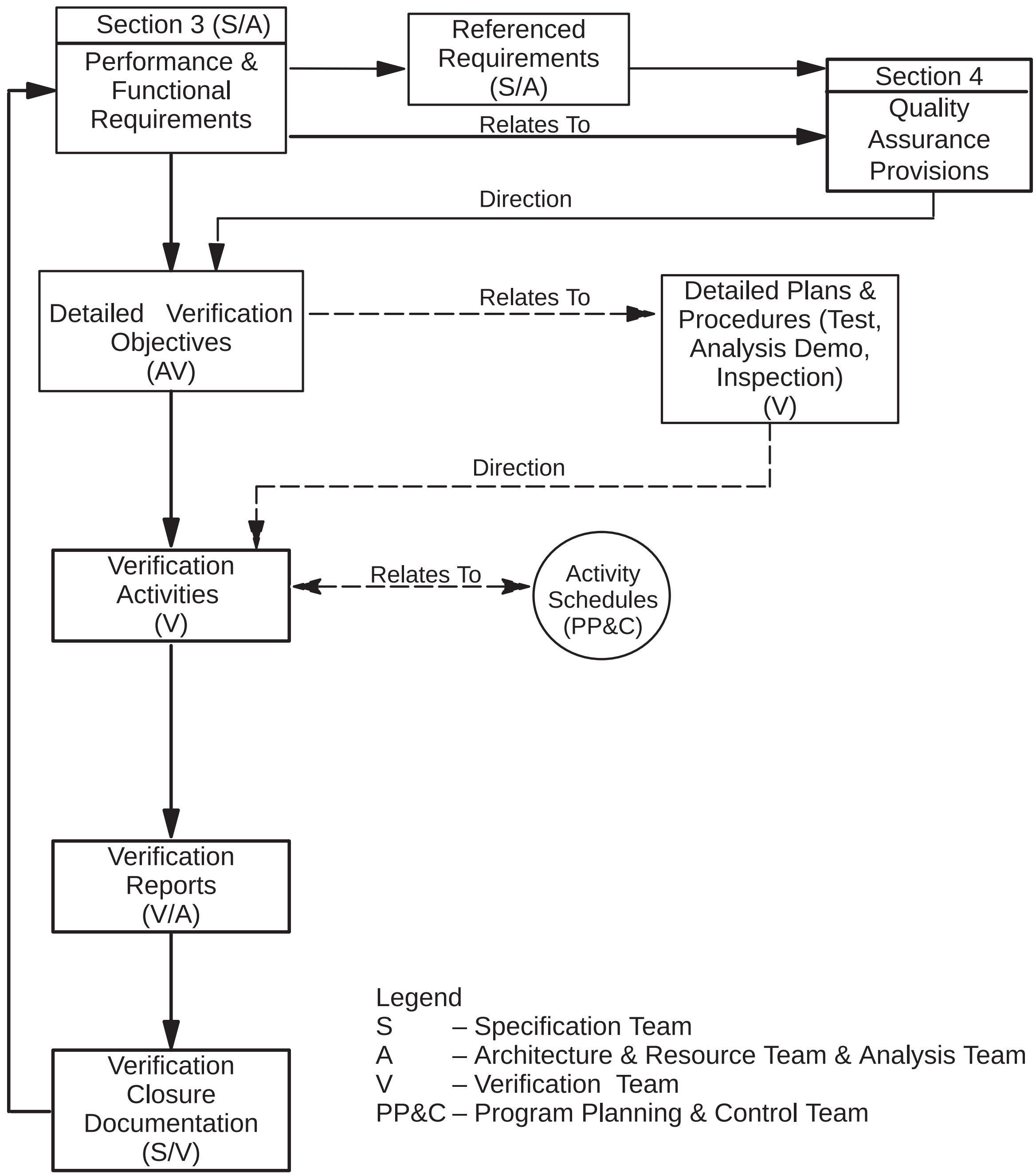


FIGURE 5–4 VERIFICATION TRACEABILITY PROCESS

An example of the requirement traceability for an ISSA capability is shown in Figure 5–5. The completed requirements traceability is then mapped against the completed functional decomposition and Assembly flights, as shown in Figure 5–6, Capability versus Flight Manifest. This mapping is used to bound the verification activities discussed in section 5.2, Define Closure Strategy.

Upward traceability of requirements in the PVIS Database will be established from:

a. The Ground Facility Prime Item Development Specifications to the USGS Specification; and,

b. The GFE requirements to the ISSA System Specification.

The International Participants will establish and maintain upward traceability of requirements from:

a. The Lower Level IP End Item Specifications to the IP Segment Specifications, including IP IRDs and ICDs Part 1, when Specification references exist.

The Product Groups' local databases capture the requirements and associated verification traceability data from the Prime Item Development specifications through verification implementation to the closure documentation. The verification process utilized by the Product Groups for capturing this data is defined in their Master Verification Plans. Verification traceability data for the Prime Item Development specifications, will be provided to the Prime Contractor via electronic transfer of data into PVIS. This process is described in the PVIS Process Document, D684–10021-1. The Product Groups will establish and maintain upward traceability of requirements from:

a. The Lower Level Configuration Item Specifications, Critical Item Development Specifications, and Software Requirements Specifications to the U.S. Prime Item Development Specifications.

The requirements traceability process, in itself, does not account for the applicable source data (e.g., NSTS, ICDs) that is related to each requirement. This related source data is used during the verification process to show compliance to each of the specification requirements. Requirement relationships will be established for each specification as described in the PVIS Process Document, D684–10021–1. When functional decomposition, requirements traceability, and comparisons are completed, associated and reference requirements are identified.

Functional Decomposition	System	RS	FGB	SM	Soyuz	CV
Control Atmospheric Pressure	3.2.1.1.1.1					
Control Total Pressure		3.2.1.1.1.1.1			3.7.6.5.1.1	
Monitor Total Pressure			3.7.1.3.1.1	3.7.2.3.1.1	n/a	3.7.7.3.1.1
Introduce Nitrogen			n/a	n/a	n/a	3.7.7.3.1.2
Store Nitrogen			n/a	n/a	n/a	n/a
Control Oxygen Partial Pressure		3.2.1.1.1.1.2			3.7.6.5.1.2	
Monitor Oxygen Partial Pressure			3.7.1.3.2.1	3.7.2.3.2.1	n/a	n/a
Introduce Oxygen			n/a	n/a	n/a	n/a
Store Oxygen			n/a	3.7.2.3.2.2	n/a	n/a
Relieve Overpressure		3.2.1.1.1.1.3	n/a	n/a	n/a	3.7.7.3.3
Equalize Pressure		3.2.1.1.1.1.4	3.7.1.3.4	3.7.2.3.4	n/a	3.7.7.3.4

FIGURE 5–5 REQUIREMENT FLOW CHART – CONTROL ATMOSPHERIC PRESSURE

ASSEMBLY FLIGHTS	1A	2A	1R	2R	3R	3A	4R	4A	5R	5A
CAPABILITY	FGB	N1, PMA1/2	SM	Soyz	UDM	Z1, PMA3, EVA	DC	P6	SPP–1GY RO	LAB, SMC
Control Atmospheric Presssure										
Control Total Pressure				x						
Monitor Total Pressure	x	x	x							x
Introduce Nitrogen		x				x				x
Store Nitrogen										
Control Oxygen Partial Pressure				x						
Monitor Oxygen Partial Pressure	x	x	x							x
Introduce Oxygen		x				x				x
Store Oxygen			x							
Relieve Overpressure										x
Equalize Pressure	x	x	x							x

FIGURE 5–6 CAPABILITY VERSUS FLIGHT MANIFEST

ASSEMBLY FLIGHTS	6A	6R	7A	8A	7R	9A	8R	10A	11A	12A
CAPABILITY	MPLM, SSRMS	SPP–2 AF	AL	SO, MT	SPP Solar Arry	S1	RM–1	N2, Cupo-la	P1	P3–P4
Control Atmospheric Presssure										
Control Total Pressure										
Monitor Total Pressure			x					x		
Introduce Nitrogen			x					x		
Store Nitrogen			x							
Control Oxygen Partial Pressure										
Monitor Oxygen Partial Pressure			x					x		
Introduce Oxygen			x					x		
Store Oxygen			x							
Relieve Overpressure	x		x							
Equalize Pressure	x							x		

FIGURE 5–6 CAPABILITY VERSUS FLIGHT MANIFEST – Continued

5.1.4 IDENTIFICATION OF REFERENCE REQUIREMENTS

Specification requirements often reference other documented requirements. Referenced requirements need to be collected and verified by the same methods as specification requirements.

The referenced document requirements are reviewed by the appropriate verification subteams. The reference requirements which are in scope for the ISSA specification requirements are identified. (For example, if the scope were limited to grounding requirements in the referenced requirements, then only the grounding requirements would be listed.)

Each requirement is then assessed for its applicability to the item. (For example, if the requirement applies only to items over 1000 pounds and this item is 500 pounds, then exclude this item for that reason).

If the reference requirement contains a reference callout, then that string of requirements is not applicable.

5.2 DEFINE CLOSURE STRATEGY

To provide compliance for each requirement, a closure strategy must be defined and implemented. This constitutes a plan by which verification activities can be executed. The verification plan has to demonstrate the path or logic flow for inter–connecting each specified verification activity for each staged assembly. Each activity or specific objective in these logic flows must provide sufficient detail to execute the activity and establish the relationships (networked) to each activity. When each specified activity has been satisfied in the logic network, then the corresponding requirement will be satisfied. Each logic flow is compared against an integration logic network to properly sequence verification activities.

The requirements to be closed are those defined in sections 3.2–3.6 of the applicable specifications. The complimentary section 4.0 quality assurance provisions are the methods of verification, conditions, and criteria for the section 3.0 requirement; however, it will require additional verification activities to attain this. For example, a requirement which is satisfied by single analysis may require data from several tests and inspections. Therefore, the logic flow of verification activities must specify these events in sufficient detail to ensure the summary analysis, and the activities are identified and scheduled to ensure compliance of the specification for assembly complete. (The logic flow required to ensure an analysis can be accomplished for an ISSA System Specification internal audio requirement for Flight 5A is shown in Figure 5–7. This logic network specifies several other analyses to complete this effort.)

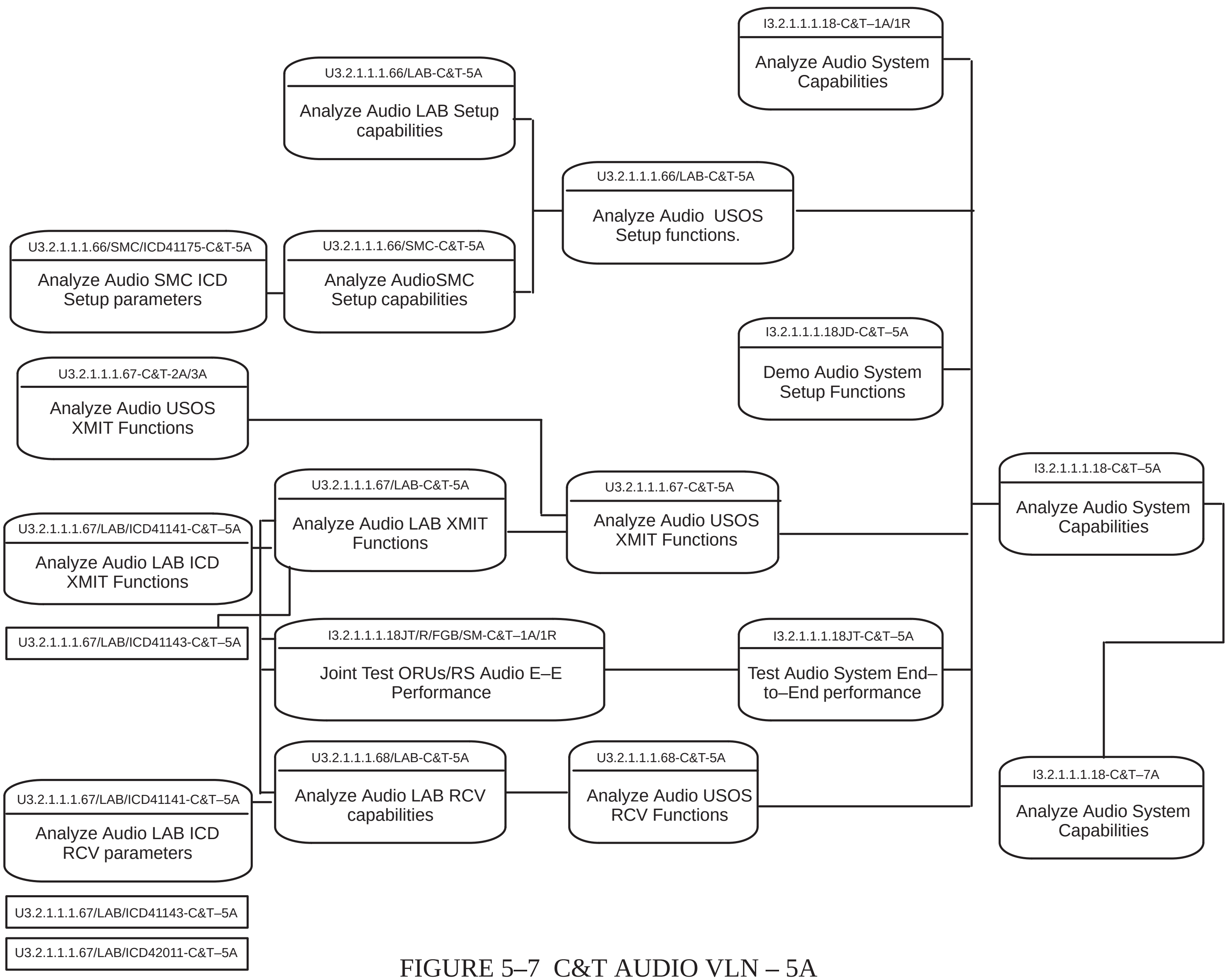


FIGURE 5–7 C&T AUDIO VLN – 5A

5.2.1 DEVELOP INTEGRATION LOGIC FLOW

The framework to construct verification logic networks has been determined by the activities described in section 5.1. To ensure the correct sequencing of verification activities, an Integration Logic Flow is prepared by the IT&V AIT. This Integration Logic Flow networks all physical activities and events to build-up the ISSA. The verification subteams compare their verification logic networks against this Integration Logic Flow to appropriately plan activities. The integration logic flow is developed using the: Assembly Sequence; the ISSA Program Schedule; Capability Description Documents, Operational Sequence Diagrams and, the Assembly Integration Requirements Document.

5.2.1.1 TEST

Test is the preferred verification method. It is a method of verification wherein requirements are verified by measurement during or after the controlled application of functional and environmental stimuli. These measurements may require the use of laboratory equipment, recorded data, procedures, test support items, or services. For all test activities, pass or fail test criteria or acceptance tolerance bands (based upon design and performance requirements) will be specified prior to conducting the test. This will ensure that the actual performance of tested equipment or systems meets or exceeds specifications. Acceptance tolerance bands used at the manufacturer's facility for component or subsystem level tests will be based on operational tolerance bands.

The tolerance band for a given specification value will take into account the following, where applicable:

a. Instrumentation accuracy

b. Facility and support equipment stimuli

c. Test specimen tolerance buildup or expected variation from specimen to specimen

d. Predicted external environmental range and uncertainty (e.g., pressure, temperature humidity, and contamination)

e. Test influence variations and

f. Component aging

The Root Sum Square (RSS) method will be the preferred method used to combine tolerances. When the RSS method cannot be used, other statistical approaches that consider all the factors affecting system accuracy will be used if specified in the test plan.

Tolerance limits must satisfy the following criteria:

a. Meet the test objective

b. Minimize the accuracy requirement of the GSE

c. Be equal to or more stringent than mission limits and

d. Be equal to or more stringent than design safety margins

Off–limit hardware testing may be conducted at the discretion of the developer. The results of all off–limit tests will be documented whether planned or unplanned. The developer's approval process for off–limit hardware testing will consider the following:

a. The preservation of qualification hardware

b. The existence of uncertainty in definition of design criteria

c. The existence of single failure points

d. The possibility of associated hardware failures creating an off–limit condition and

e. Where design safety margins cannot be met, but a positive margin of safety exists

New, nondestructive testing techniques or new applications of old techniques will be verified during development.

Testing of subsystems and components installed in a flight element will use available operational signals and software as stimuli or alternate developer approved methods. Interface verification by test will use flight HW/SW, simulators, or interface tooling. Software tests will include the following:

a. Nominal and off–nominal data and operating conditions

b. System performance at minimum, nominal, and maximum level of system activity

c. Verification of the ability to detect, diagnose, and recover from hardware and software faults

5.2.1.2 ANALYSIS

Analysis is a method of verification utilizing techniques and tools such as computer and hardware simulations, analog modeling, similarity assessments, and validation of records to confirm that design requirements to be verified have been satisfied. Analysis may also be the evaluation of the results of multiple tests and analyses at a lower level as it would apply to a higher level of assembly. Analytical methods selected for verification will be supported by appropriate rationale and be detailed in the applicable documents. Analysis may be used whenever any of the following apply:

a. The spectrum of flight conditions cannot be simulated adequately on the ground and it is necessary to extrapolate test data beyond the performed test points

b. It is not cost effective to test

c. It is necessary to confirm that software complies with applicable coding standards

d. It is desired to determine closure status of verification activities being performed at lower levels of assembly to support closures at higher levels

Most analyses will be accomplished in the development and qualification phases of verification. Similarity is a form of analysis that is acceptable for qualification (where it is shown that the article is similar in design, manufacture, manufacturing process, and quality control to another article that has been previously qualified to equivalent or more stringent criteria). However, additional analyses may be performed to support acceptance of larger assemblies and integration activities.

Distinguished from qualification by analysis are analyses used to support qualification by test. Examples of these analyses are: (1) analyses used to make pretest predictions to size fixtures and determine sensor locations; (2) analyses carried out during tests to provide reasonableness checks on data; (3) analyses carried out to examine unexpected results; and (4) post test analyses to convert test data into engineering units.

5.2.1.3 INSPECTION

Inspection – a method of verification of physical characteristics that determines compliance of the item with requirements without the use of special laboratory equipment, procedures, test support items, or services. Inspection uses standard methods such as visuals, gauges, etc., to verify compliance with requirements. Hardware may be inspected for the following:

a. Construction

b. Workmanship

c. Physical condition

d. Specification and/or drawing compliance

A pretest inspection will be performed prior to all testing of ISSA hardware and software to ensure that the test configuration is correct. A post test inspection will be performed after all testing of ISSA hardware and software to identify and record any deleterious test effects. Inspection may be used to confirm that ground/flight software complies with applicable coding standards. Inspection may be used to confirm that engineering drawings call out proper design and construction features (i.e. materials and processes). Inspection includes review of design (ROD).

5.2.1.4 DEMONSTRATION

Demonstration – a method of verification used for determination of properties of an end item or component by observation of its operation or characteristics. It will be employed where qualitative operational performance requirements are to be verified. When used as a formal verification activity, demonstrated performance will be observed and recorded. Demonstration is used with or without special test equipment or special instrumentation to verify characteristics such as operational performance, human engineering features, maintainability, built in test/built in test equipment transportability and display data. As an example, demonstration will most likely be used to verify maintainability requirements of reach, accessibility, clearances, etc., in an underwater test facility using crew members interacting with mockups constructed for such use. Some demonstrations may be done as a part of development activities. Interface verification by demonstration will use flight HW/SW, simulators or interface tooling.

The verification subteams will prepare VLNs for all ISSA System and USOS Specification requirements, joint activities, (U.S. side) specified in IRDs, and the Station Management and Control (SM&C) B–1 Specification. Pertinent details of the Product Group Contractor, International Partner, and NASA Institution requirements will be included to define specific verification data required to be assigned for the closure of the USOS and ISSA Specifications. (This is further discussed in the following sub–step and section 6.0).

5.2.1.5 IP AND KhSC VERIFICATION METHODS

The IPs and KhSC, in general, use differently named verification methods than the U.S. does. The correlation between the U.S. and the IPs will be included in the applicable BI&VP. KhSC correlation is included in the LMSC/KhSC statement of work, Appendix E.

5.2.2 PREPARE VERIFICATION LOGIC NETWORK (CLOSURE STRATEGY)

Before a requirement can be closed, a closure strategy needs to be developed. This strategy is documented in a Verification Logic Network (VLN), as shown in Figure 5–8. A VLN is a graphical depiction of closure strategy. Initially developed by hand, the VLN contains:

a. A set of logic gates, which define the interdependencies between verification activities

b. A specific set of activities (objectives to be executed)

The verification activities indicated on a VLN are simple/summary objectives. These objectives indicate whether a test, demonstration, inspection or analysis must be conducted to support closing the requirement. (One of these objectives must be the complimentary Specification section 4.0 quality assurance provision). This hand drawn illustration depicts the planned closure strategy and can then be expanded to define the DVOs. VLN reports are generated from PVIS based on the logic flow of the objectives.

The VLN is constructed for each subsystem in the following order, i.e.:

a. Define the complete subsystem – Verification subteam personnel must understand the end-to-end subsystem and specifically what other subsystems are dependent or supportive. This sub-step also determines the secondary ownership of a requirement (discussed in section 5.1.1). For example, an extra-vehicular robotic requirement is dependent on power (Electrical Power Subsystem), thermal criteria (Thermal Control Subsystem), data (Command and Data Handling Subsystem), and command capability (Command and Control Subsystem). This information allows the verification subteam to determine the relevant aspects necessary for each functional area, such as required data, supporting subsystems, and associated hardware.

b. Determine methods to verify end-to-end functionality – Each verification objective assigned on a VLN must specify the verification method to be used. The assignment is determined through the Method Selection Process, depicted in Figure 5–9. The criteria for the methods are described in sections 5.2.1.1–5.2.1.4.

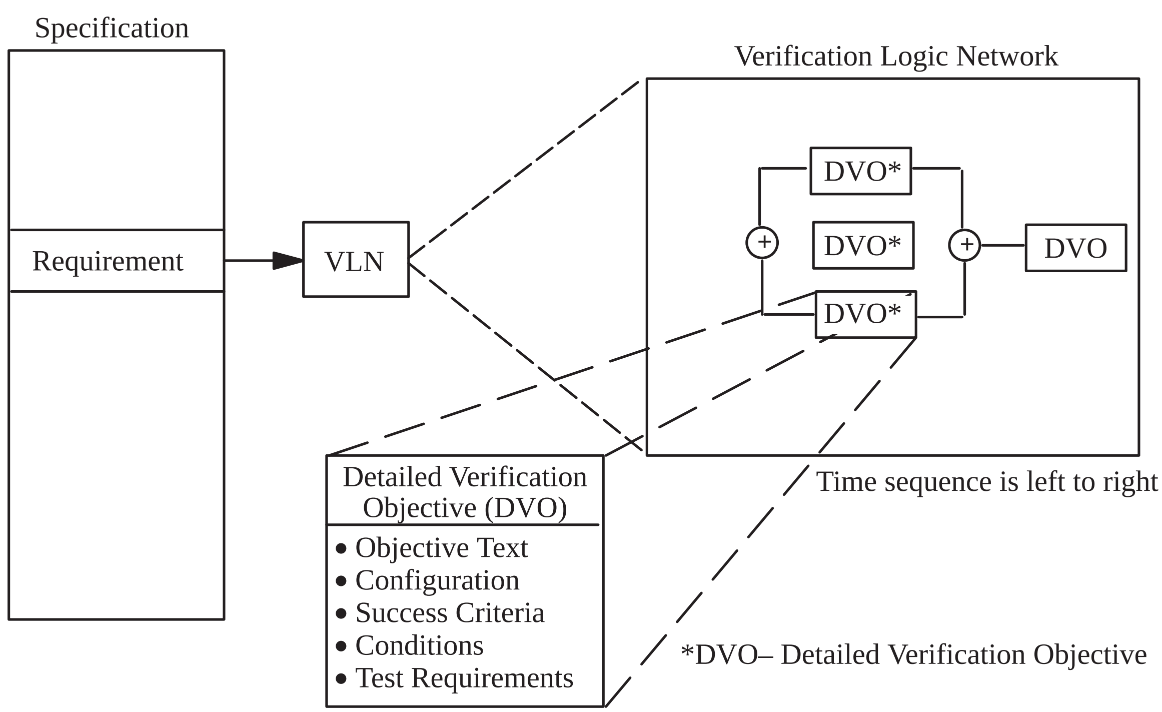


FIGURE 5–8 VERIFICATION LOGIC NETWORK

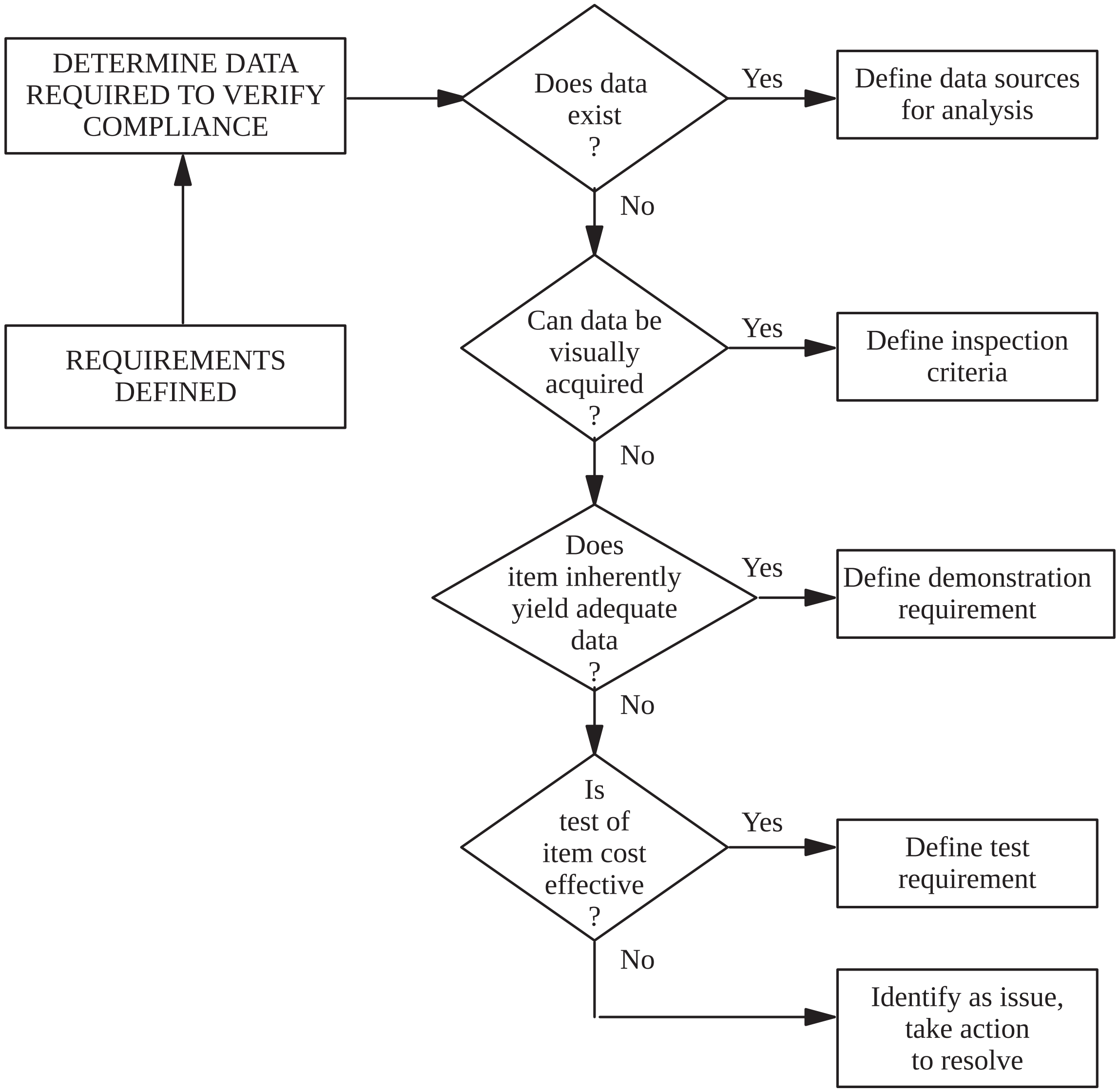


FIGURE 5–9 METHOD SELECTION PROCESS

c. Identify the applicable stages – for which the end-to-end functionality must be verified. This should be tied to the launch date of the first piece of hardware in the end-to-end path. This can be accomplished using both the integration logic flow (see section 5.2.1) and the assembly sequence.

d. Construct the VLN – The VLN flows right–to-left and begins with the activity defined in the corresponding section 4.0 of the ISSA System Specification. The VLN ends when the last objective verifies the subsystem to the lowest applicable level. (The VLN contains simple verification objectives logically tied together). The completed VLN will link DVOs by stage assembly.

e. Construct "Short Form" DVOs – Each "short form" DVO should include:

- Objective – title, text statement of the objective and verification method
- Flight number – the applicable assembly flight
- Configuration – unique assembly configuration

f. Validate the VLN – by presenting the VLN to the IT&V AIT technical review panel. This panel will check for technical feasibility, logic relationships, and sequencing against the integrated logic flow. Once this activity is complete, the VLN is entered into PVIS.

5.2.3 DEFINE DETAILED VERIFICATION OBJECTIVES (DVO)

The “short form” DVOs on a VLN need to be sufficiently expanded to specific details to be able to execute the activity. This completed detail creates a DVO, otherwise known as the “long form” DVO. In general. the type of information required by a DVO includes:

a. Objective – Title, text statement of the objective and verification method

b. Flight Number – applicable assembly flight number for each DVO

c. Configuration – Unique assembly configuration to be analyzed, inspected or tested (includes Vehicle Master Database (VMDB) item part number)

d. Success Criteria – “quantitative” success criteria

e. Conditions – expected modes of operation, applicable verification process requirements, conditions to be imposed for testing or analysis

f. Organizations – responsible and implementation organizations

g. Test Requirements – specific test requirements necessary to accomplish verification

h. Status – completion status

i. Program Constraints – program milestone constraints for the DVO

j. Prerequisite Objectives – prerequisite objectives required to satisfy the DVO

The DVO form will be used to collect this data, as shown in Figure 5–10, DVO Form. This information is then input to the PVIS database. (Additional detail is described in Verification Training Session #2 materials, available from the IT&V IPT.) Note: After

VLN information is entered into PVIS, these forms will be provided to the verification subteam for completion (VCN preparation).

Each verification activity which was identified by the requirements traceability mapping in Step #1 needs to be addressed as a DVO. Figure 5–11, Requirements/DVO Breakdown, depicts the scope of DVOs required. This map then bounds the activities necessary to comply with the specification requirement.

After DVOs are developed, this information is entered in PVIS by the IT&V AIT. Logic relationships are established and linked to Product Group and IP activities.

5.2.4 IDENTIFY STAGE-UNIQUE DVOs

After the activities of 5.2.2 and 5.2.3 are completed, stage–unique DVOs will be generated by PVIS. Stage-unique DVOs are determined by the verification subteams when the VLN is generated. PVIS, then constructs stage-assembly VLNs (using the DVO data) and completes the logic ties. This step ensures stage–unique verification requirements are appropriately satisfied to support the assembly–complete verification. Additionally, this effort ensures integration and mandatory ordering of verification activities can be accomplished.

Once the stage-assembly VLN is generated, it will be evaluated against AIRDs, FDD, CDDs, and the assembly sequence for compatibility and feasibility, as part of the verification activity comparison, discussed in section 5.2.6.

<table>
<tr><th colspan="12">DETAILED VERIFICATION OBJECTIVE (DVO)</th></tr>
<tr><td colspan="4">1. DOCUMENT ID:</td><td colspan="4">2. RQMT ID:</td><td colspan="4">2. DVO #:</td></tr>
<tr><td colspan="4" rowspan="2">4. RQMT PARA # (SEC 3)</td><td colspan="8">5. RQMT PARA TITLE: (SEC 3)</td></tr>
<tr><td colspan="8">6. PRIMARY VERIFICATION RESPONSIBILITY (SEC 3):</td></tr>
<tr><td colspan="12">7. RQMT TEXT (SEC 3)</td></tr>
<tr><td colspan="12">8. VERIFICATION RQMT TEXT (SEC 4)</td></tr>
<tr><td colspan="6">9. ASSOCIATED RQMT PARA #(S):</td><td colspan="6">10. REFERENCE RQMT PARA #:</td></tr>
<tr><td colspan="12">11. DETAILED VERIFICATION OBJECTIVE TITLE/TEXT: METHOD:</td></tr>
<tr><td colspan="12">12. SUCCESS CRITERIA:</td></tr>
<tr><td colspan="12">13. CONDITIONS:</td></tr>
<tr><td colspan="6">14. PROGRAM MILESTONE CONSTRAINTS:</td><td colspan="6">15. PREREQUISITE DVO CONSTRAINTS:</td></tr>
<tr><td>PDR</td><td>IDR</td><td>AR</td><td>ORR</td><td colspan="2">OTHER</td><td colspan="6" rowspan="2"></td></tr>
<tr><td>CDR</td><td>FCA</td><td>PCA</td><td>FRR</td><td colspan="2"></td></tr>
<tr><td colspan="6">16. LEVEL OF IMPLEMENTATION:</td><td colspan="6">17. IMPLEMENTING ORGANIZATION:</td></tr>
<tr><td colspan="2">ORU</td><td colspan="2">LCH PKG</td><td colspan="2">SEGMENT</td><td>Prime</td><td>LP</td><td>PG 1</td><td>PG 2</td><td>PG 3</td><td>GND</td></tr>
<tr><td colspan="2">END ITEM</td><td colspan="2">STAGE</td><td colspan="2">ISSA</td><td>ESA</td><td>CSA</td><td>RSA</td><td>NASDA</td><td>ASI</td><td>OTHER</td></tr>
<tr><td colspan="6">18. UNIQUE RESOURCES NEEDED:</td><td colspan="6">19. CONFIGURATION: (VMDB ITEM P/N & NAME)</td></tr>
<tr><td colspan="12">20. DVO APPROVAL:
_______________ Prime   _______________ NASA</td></tr>
<tr><th colspan="12">VERIFICATION COMPLETION NOTICE (VCN)</th></tr>
<tr><td colspan="8" rowspan="3">21. COMPLETION DOCUMENTS:</td><td colspan="4">22. DVO STATUS:</td></tr>
<tr><td>BASELINED</td><td></td><td>DELETED</td><td></td></tr>
<tr><td>PROPOSED</td><td></td><td>VERIFIED</td><td></td></tr>
<tr><td colspan="12">23. VERIFICATION COMPLETION APPROVAL:
_______________ Prime   _______________ NASA   _______________ DATE:</td></tr>
</table>

FIGURE 5–10 DVO FORM

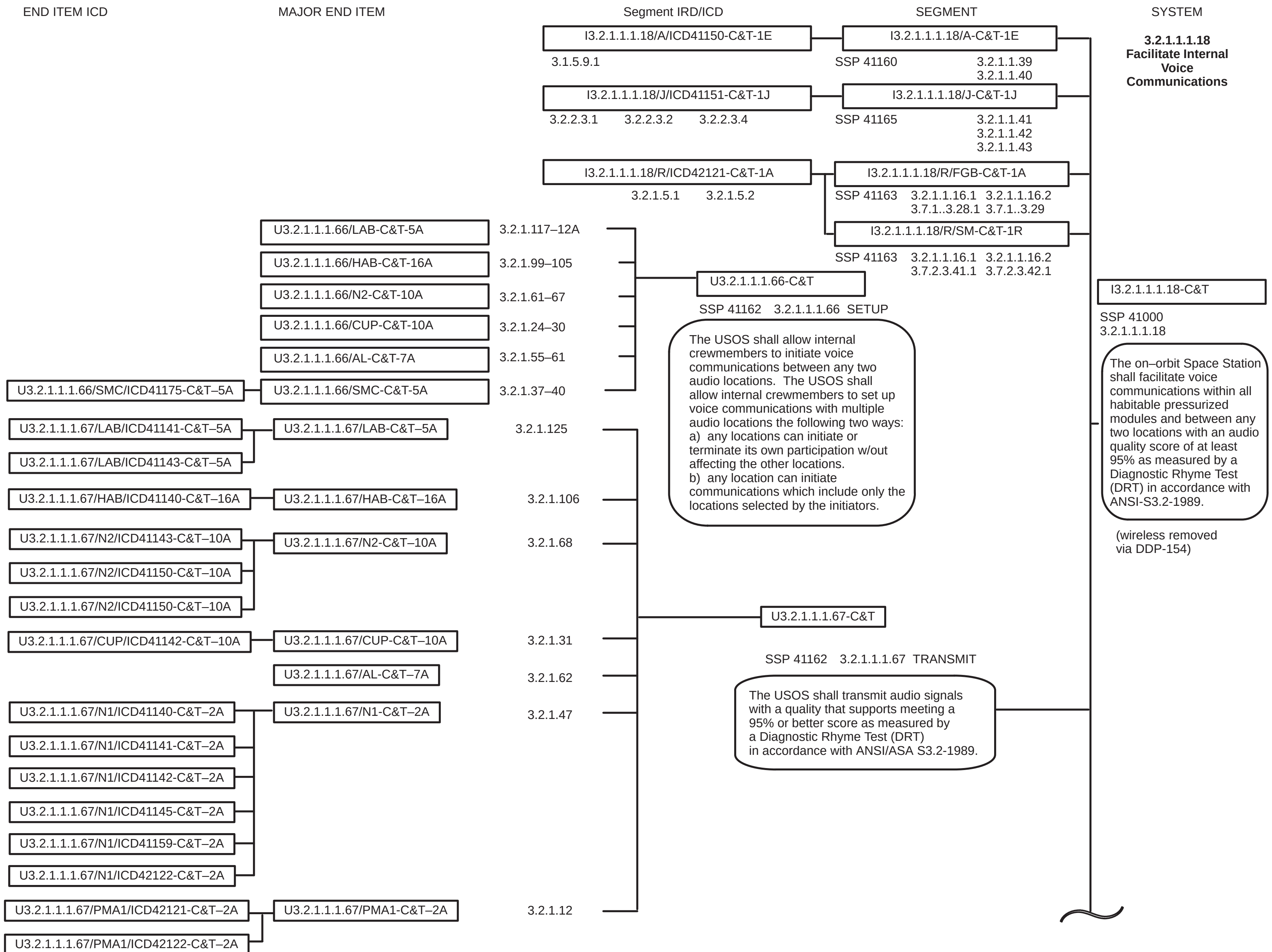


FIGURE 5–11 REQUIREMENT/DVO BREAKDOWN

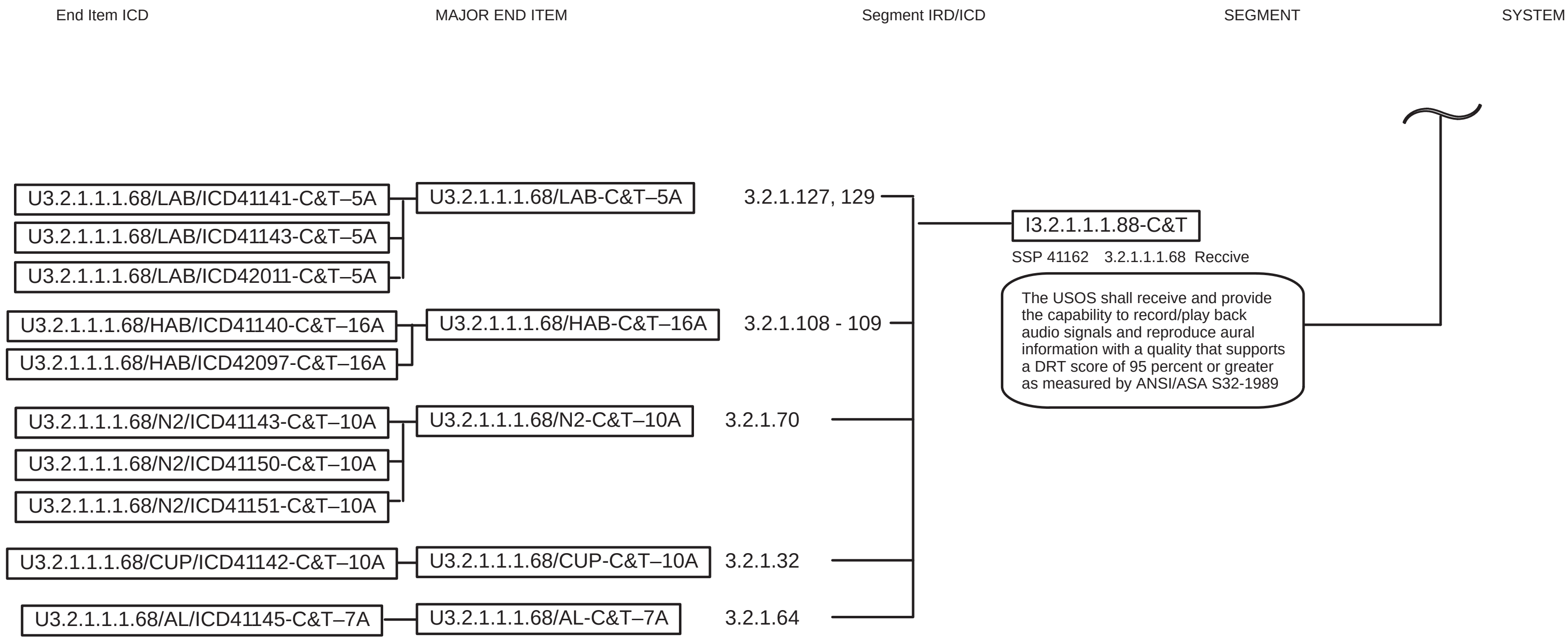


FIGURE 5–11 REQUIREMENT/DVO BREAKDOWN – Continued

5.2.5 COMPLETE DETAILED VERIFICATION REQUIREMENTS

Once all assembly–complete VLNs and DVOs are constructed, Detailed Verification Requirements (DVRs) are generated. DVRs are logical collections of DVOs to ensure specified requirements traceability supports the closure strategy.

DVRs are used to prepare test procedures, plans, demonstrations, inspections, analysis models, etc. DVOs with similar grouping characteristics are included in the same DVR. (For example, all passive thermal analysis DVOs, for the same configuration item, are grouped in the same DVR). Figure 5–12, Detailed Verification Requirement shows the relationship between DVOs, VLNs, and DVRs.

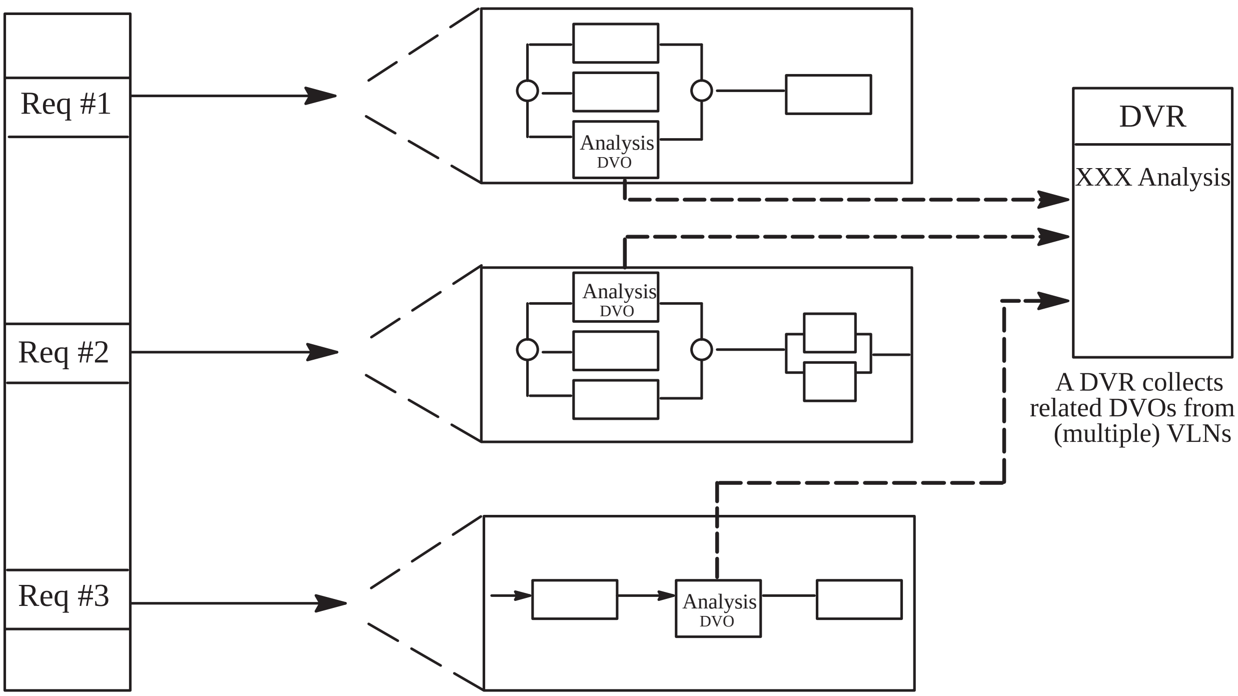


FIGURE 5–12 DETAILED VERIFICATION REQUIREMENT (DVR)

Once DVRs have been generated, they will be evaluated for completeness and technical content. This ensures:

a. All specification requirements have been addressed – all objectives needed to supply data for analysis have been defined; each DVO has entries for objective, success criteria, conditions, and test requirements (if required)

b. Each success criteria is measurable and quantitative – each analytical model needed for qualification has been identified; each referenced document is under configuration control; item configuration is unambiguously defined; dependence upon lower tier activities has been identified, including the Product Groups needs; test and support equipment requirements have also been identified

Once DVRs are compiled and checked, verification activities can be allocated to the appropriate organization (PG's, IPs, Prime Test...) for implementation. This is further discussed in section 6.0.

5.2.6 VERIFICATION ACTIVITY COMPARISON

Verification activity comparison is conducted by the IT&V AIT in two steps: (1) evaluation of assembly-complete VLNs and short-form DVOs; and, (2) long-form DVOs. The first part of the evaluation is conducted when VLNs are generated by the verification subteam. The second part of the IT&V AIT comparison is conducted by a joint panel which includes the VAIT and SAIT.

Evaluation of assembly-complete VLNs and short-form DVOs will be based on:

a. Technical feasibility

b. Logic relationships

c. Sequencing against the integrated logic flow

d. Schedule and budget constraints

e. I&VIP implementation

The results of this evaluation are incorporated into the VLN and short-form DVOs.

A technical review of the long-form DVOs will be conducted prior to implementation.

After all assembly complete DVOs are defined by the Prime Contractor, these specific activities are compared with efforts planned by the Product Group Contractor and International Participants. This effort is conducted to ensure all closure activities are planned. Allocation of any new or “delta” activities will be done as described in section 6.1.1.

5.3 PRIME TO SUBCONTRACTOR INTERRELATED VERIFICATION PROCESSES

The Prime Contractor is responsible for verifying the ISSA System and USOS Specification requirements. The Product Groups and Lockheed Missiles and Space Corporation (LMSC) are responsible for verifying contract end item requirements. The Product Group 3 process is essentially the same as the Prime's process just described. Product Group 1 and Product Group 2 use differing processes, as defined in their respective MVP's, that are similar to the Prime Contractor's methodology.

The ISSA Verification Program process requires that Product Groups and LMSC demonstrate traceability from all specification sections 3.0 and 4.0, by their method of verification, to the applicable Qualification Procedure or Report number (exceptions to this will be accepted upon Prime-to-PG Contractor/LMSC agreement that on equivalent traceability process is in place). The Product Groups and LMSC will show traceability from each of these paragraphs to the associated compliance data and test reports, and will demonstrate end–to–end traceability to the Prime Contractor. Traceability data shall be available for review by the Prime Contractor.

The Product Group 1 verification process is shown in Figure 5–13, Product Group 1 Verification Process. Product Group 1 will establish detailed verification requirements. These detailed verification requirements will be maintained in McDonnell Douglas Aerospace (MDA) internal documents.

Specification requirements traceability and compliance data will be available through a common relational database which serves both PVIS and the PG-1 Requirements Traceability/Verification Tracking System.

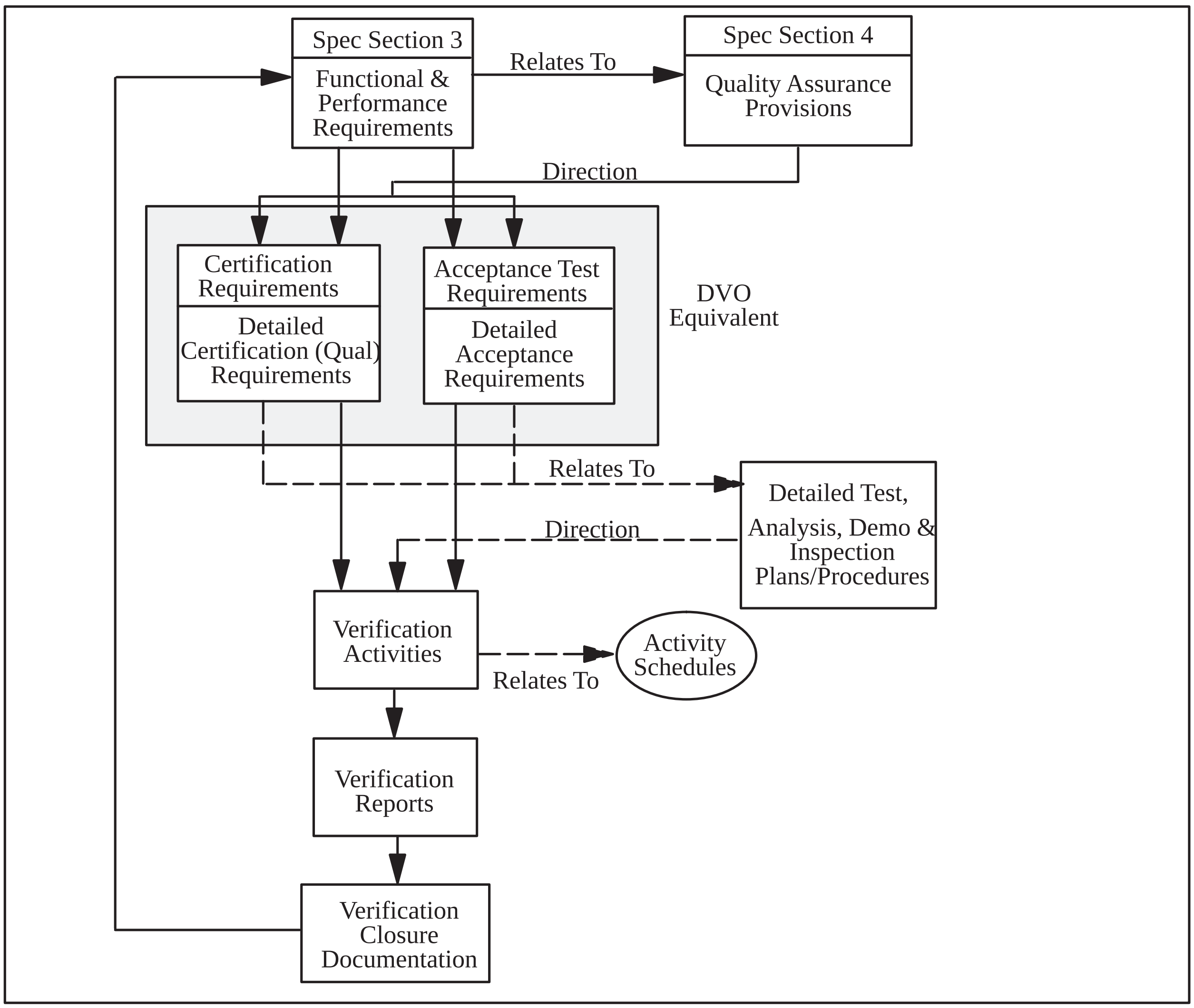


FIGURE 5–13 PRODUCT GROUP 1 VERIFICATION PROCESS

The Product Group 2 verification process is shown in Figure 5–14, Product Group 2 Verification Process. This Product Group will associate each section 3.2–3.6 requirement with one of the four quality assurance provisions in a Verification Cross Reference Index (VCRI) in accordance with the corresponding section 4.0. The Product Group 2 process interrelates to the Prime Contractor process by providing the VCRI and closure documentation, as discussed in section 4.4. Additionally, verification closure data will be made available to the Prime Contractor via the Data Accession List. The Electrical Power System Database (EPSD) Verification Report Index indicates the closure documentation.

The FGB will be verified by Krunichev using their normal verification process. LMSC will oversee and monitor this process for Boeing/NASA, and will be responsible for entering PVIS data to show the closure of the requirements of the FGB specification. The closure data will provide pointers to the test plans and reports that document the verification activities.

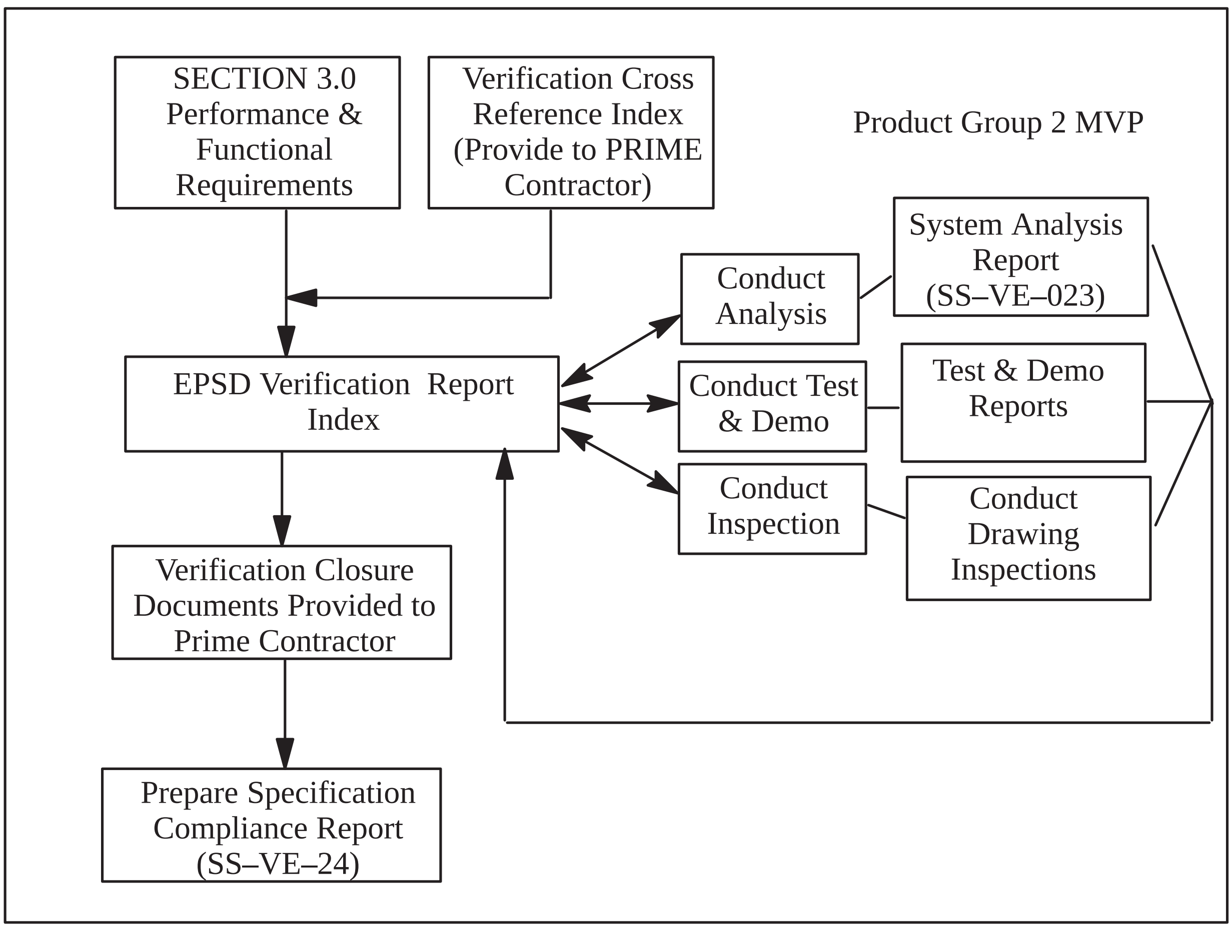


FIGURE 5–14 PRODUCT GROUP 2 VERIFICATION PROCESS

5.4 JOINT VERIFICATION ACTIVITIES

As depicted on Figure 1–1, there are joint verification activities that are accomplished between the USOS and the IPs, USGS and NSTS. These joint verification activities are identified during the conduct of steps 1 and 2 of the Five-step Verification process.

Closure of these joint activities will be accomplished using the methodology discussed in section 7.0 of this document. A description of the various joint verification activities is found in the following paragraphs.

U.S. interface verification requirements are developed cooperatively by the Verification Team, Interfaces Team, Subsystem Teams and Specification Team in conjunction with the IPs. Joint verification requirements for NASA–to–IP interfaces require negotiation and agreement with the respective IP and then documented in the applicable BI&VP.

Those defined efforts which require verification activities to be performed on the U.S. side will be documented in the I&VIP. Traceability to the ISSA System Specification Requirements will be maintained in the PVIS database.

The determination of whether a verification activity should be joint is based on engineering judgement of the criticality of the subsystem function to the overall Space Station. Also, the extent of support from each interfacing partner, is based upon the operational impact if the function were to be inoperable due to interface incompatibility.

Following is a definition of joint verification activities with IPs. This definition will be included in each BI&VP. Joint verification is an activity performed by one partner with active participation by the other partner(s) to verify the requirements in the applicable interface documents.

Active participation includes provisioning of U.S. hardware/software to an IP, or IP hardware/software to the U.S., for verification/integration and one or more of the following:

a. Installation and/or training in the operation of the provided HW/SW

b. Development of verification objectives

c. Verification planning

d. Verification implementation and documentation

e. Requirement compliance determination and documentation

Roles, responsibilities, and objectives for joint verification will be bilaterally agreed to and documented in the applicable Bilateral Integration and Verification Plan (BI&VP).

This definition also applies between NASA organizations (i.e., between NASA ISSA and NASA NSTS, and NASA MOD/USGS and NASA PMO/Prime). For these cases, roles, responsibilities and objectives will be agreed to and documented in the applicable Joint Verification Plans.

5.4.1 IP (ESA, NASDA, RSA)

5.4.1.1 IRD/ICD PART 1 SECTION 4.0

The agreed–to U.S. and IP interface verification requirements are documented in a matrix contained in IRDs/ICD Part 1s. For an example of the matrix, see Figure 5–15.

Each requirement in section 3.0 of the IRD/ICD Part 1 document will be listed on the left, by requirement number and title. Requirements in the IRD/ICD Part 1 which will require joint verification will show a verification method in the right most column in the matrix. The U.S. and IP will be responsible to show verification closure through this method in order to close the section 3.0 requirement.

For each joint verification activity, a verification requirement statement will be developed and included in section 4.0 of the IRD/ICD Part 1. The verification requirement will include the verification Method, Conditions, and Success Criteria. These verification requirements will be under Space Station Control Board (SSCB) control; agreement to perform the joint activities will be documented in the applicable BI&VP.

5.4.1.2 INTERFACE VERIFICATION VISIBILITY REPORT

For each individually verified specification section 3.0 interface requirement, Individual Verification responsibility is indicated in the section specification 4.0 verification matrix with an “X”. The “X” signifies that the indicated partner will be individually responsible for performing the verification needed to close the section 3 requirement. Method and verification requirements text for individual verification requirements will not be shown in the IRD/ICD Part 1. They will be documented in the applicable U.S. or IP specification, and then compiled, reported and exchanged through the Interface Verification Visibility Report (IVVR) (for more information on the IVVR, see paragraph 4.4.3.12).

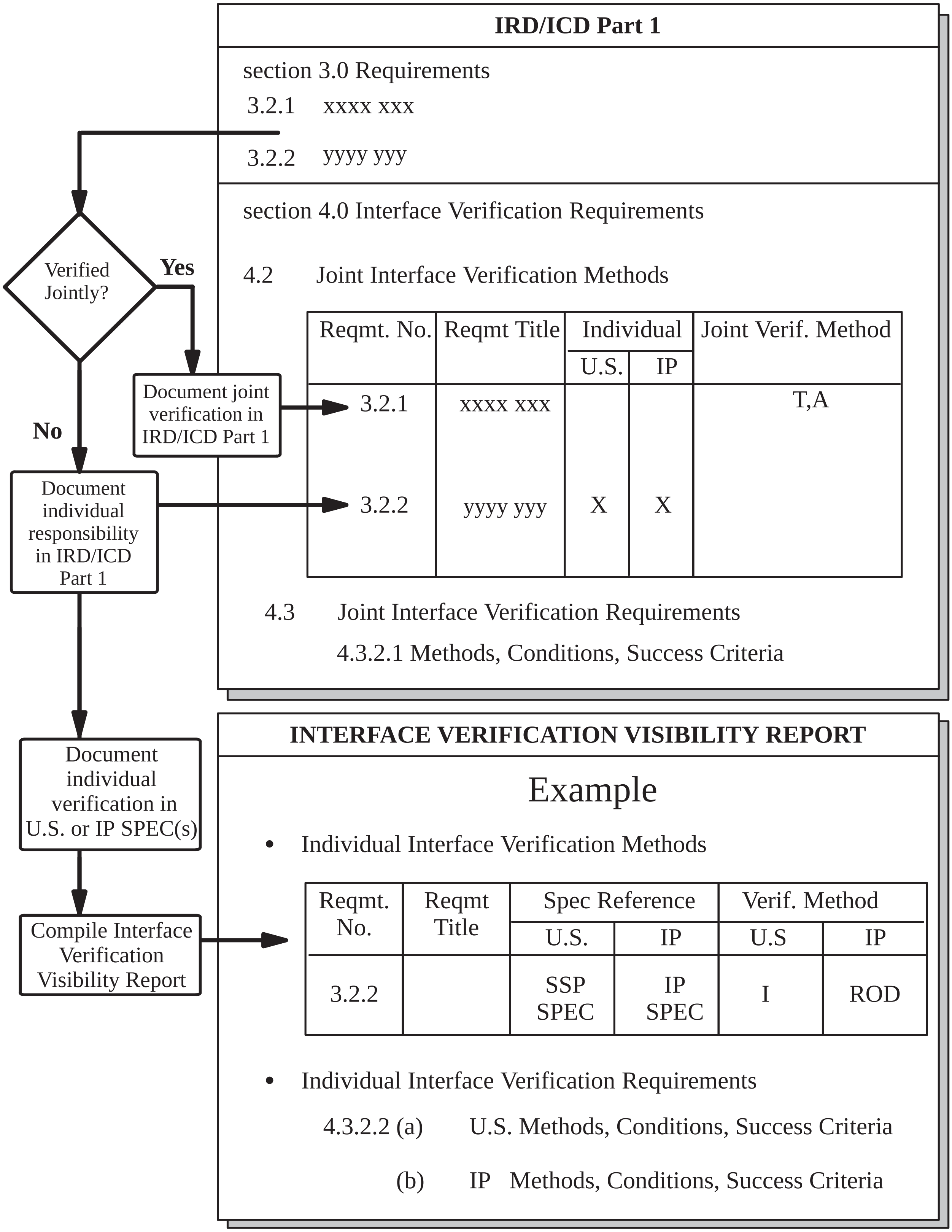


FIGURE 5–15 IP INTERFACE VERIFICATION DOCUMENTATION PROCESS

5.4.2 IP (ASI, CSA)

For NASA–to–ASI and NASA–to–CSA verification, parallel verification requirement content will appear both in the US Specifications and the International Specification or International verification documents. IVVRs are not required for CSA or ASI.

5.4.3 US GROUND SEGMENT INTERFACE

To ensure the ISSA verification philosophy described in this document is consistently applied across the program, new or modified USGS development will meet the intent of the “Five Step Verification Process”. Implementation of the verification approach used for new or modified USGS will be approved by the IT&V Team.

The Prime Contractor will obtain appropriate concurrence of USGS specification compliance to ensure their completeness and correctness. Verification compliance will be documented in the PVIS.

Joint verification activities are derived by the Five-Step Verification Process and agreed to between the IT&V interface team and NASA MOD. These agreements and tests plans will be described in Joint Verification Plans or equivalent documents, and detailed in jointly approved implementation documents. ISSA activities performed in support of joint interface verification will be documented in the I&VIP when authorized. Individual (USOS or USGS) verification activities on each side of the interface are the responsibility of either the IT&V team or NASA MOD as applicable. Verification of the USOS side of the interface will be in accordance with the philosophy and approach presented in this document.

However, facilities that are covered by the USGS specification will be integrated and verified by the ISSA Operations (AIT). The Operations AIT will certify their compliance for the program. Except for USGS facilities, NASA MOD is responsible for verifying USGS elements.

5.4.4 NATIONAL SPACE TRANSPORTATION SYSTEM INTERFACE

Steps #1 and #2 of the Five-step Verification Process identify specific requirements and verification activities which determine ISSA/Shuttle integration efforts. These joint ISSA and Shuttle efforts will be described in joint verification plans or equivalent documents, and detailed in jointly approved implementation documentation when authorized.. Closure of those DVOs will be accomplished in the same manner as defined in Steps #3-5 (see sections 6.0 and 7.0).

5.5 PAYLOAD INTERFACE

As shown on Figure 1–1, an interface is identified between the ISSA and Payloads for non-joint activities. This document does not apply to ISSA/Payload verification activities. These activities are the responsibility of the Science and Utilization AIT. See section 9.0 of this document for a general description of Payload activities. This document, however, does apply to the verification of the ISSA side of the interface with the Payload and is included in the IT&V team Five-step Verification process.

6.0 IMPLEMENT VERIFICATION ACTIVITIES

Step #3 of the Five-step Verification Process is shown in Figure 6–1.

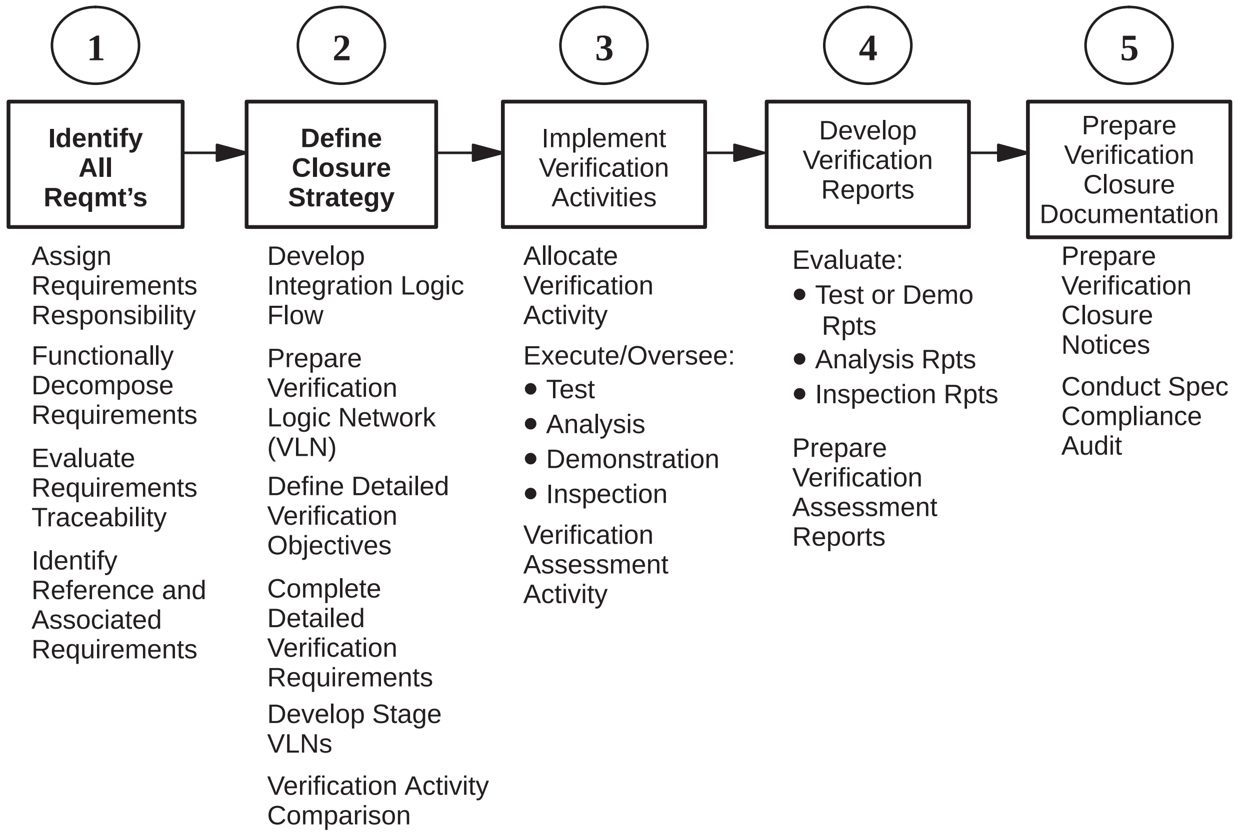


FIGURE 6–1 PRIME CONTRACTOR'S FIVE–STEP VERIFICATION PROCESS

Section 6.0 describes:

a. The methods used to compare Prime verification activities (defined in steps #1 and #2) against those activities being performed by the Product Group Contractors and International Participants and NASA Institutions.

b. The general process required to allocate those activities to Product Group Contractors, International Participants, or NASA Institutions

c. Execution of verification activities, including: analyses, inspections, tests, demonstrations, development tests, qualification activities, and flight article acceptance efforts

The approach to be used for verification assessments of Product Group Contractors, newly developed GFE and International Partners is discussed in section 4.3.2.2.

6.1 ALLOCATION OF VERIFICATION ACTIVITY

6.1.1 DEFINITION

The verification activity comparison performed in Step #2 compared the closure plans of the Prime, Product Groups, International Participants, or NASA. Those efforts which are not planned and are defined as part of the Prime's closure strategy need to be scrutinized for:

a. Technical requirement legitimacy

b. Budget constraints

c. Schedule constraints

Any new or “delta” system and segment level verification activities that were identified must next be allocated. This allocation will be accomplished by task order (or modification to the PG SOW), inclusion into the BI&VPs and/or Bilateral Data Exchange Lists (negotiated between NASA and the IPs), or technical task agreement, respectively. Figure 6–2 depicts the distribution of verification activities.

Engineering changes required to implement Verification activities, will be prepared by the Prime Contractor in accordance with the ISSA program change process. Once the engineering change is approved, either a task order will be prepared by the IT&V team or the PG Statement of Work will be modified. As such, this allocation will be made through and documented in the I&VIP.

DVOs which require inputs from or execution by the IPs will be negotiated through the NASA/IP Bilateral Integration & Verification Plans and the data requirements will be documented in the Bilateral Data Exchange List.

TTAs will be used to identify and authorize verification efforts that are to be accomplished by a NASA institution. TTAs are negotiated by the appropriate AIT/IPTs with NASA center institutions to accomplish specific tasks, which include providing GFE, producing products required by the Product Groups, or Prime, and providing specific Institutional expertise to an AIT/IPT. For additional information see paragraph 4.3.2.3.

6.1.2 IMPLEMENTATION

Those delta activities identified in paragraph 6.1.1 directly support verification closure for the Prime Contractor and will require participation by the Prime in the development, qualification, or acceptance testing program performed by the Product Group Contractor. The Prime will participate from test planning through test execution (through their on–site representative). Because the Prime is responsible for the performance of verification activities allocated to the PGs, the Prime has approval authority of the associated PG activities and tasks.. The Prime will strive for approvals to be done on a non-interference basis by early identification to the PGs of the activities to be approved. The following sections define Prime Contractor requirements for testing to be completed in support of both Prime specification compliance as well as Product Group efforts. The Prime Contractor will review Product Group tests and demonstrations as planned in the I&VIP.

6.2 DEVELOPMENT ACTIVITIES

6.2.1 DEVELOPMENT TESTING AND ANALYSIS

These are activities performed by a Product Group Contractor or the Prime, to prove a given design approach or to minimize technical risks and to assist in detailed design engineering

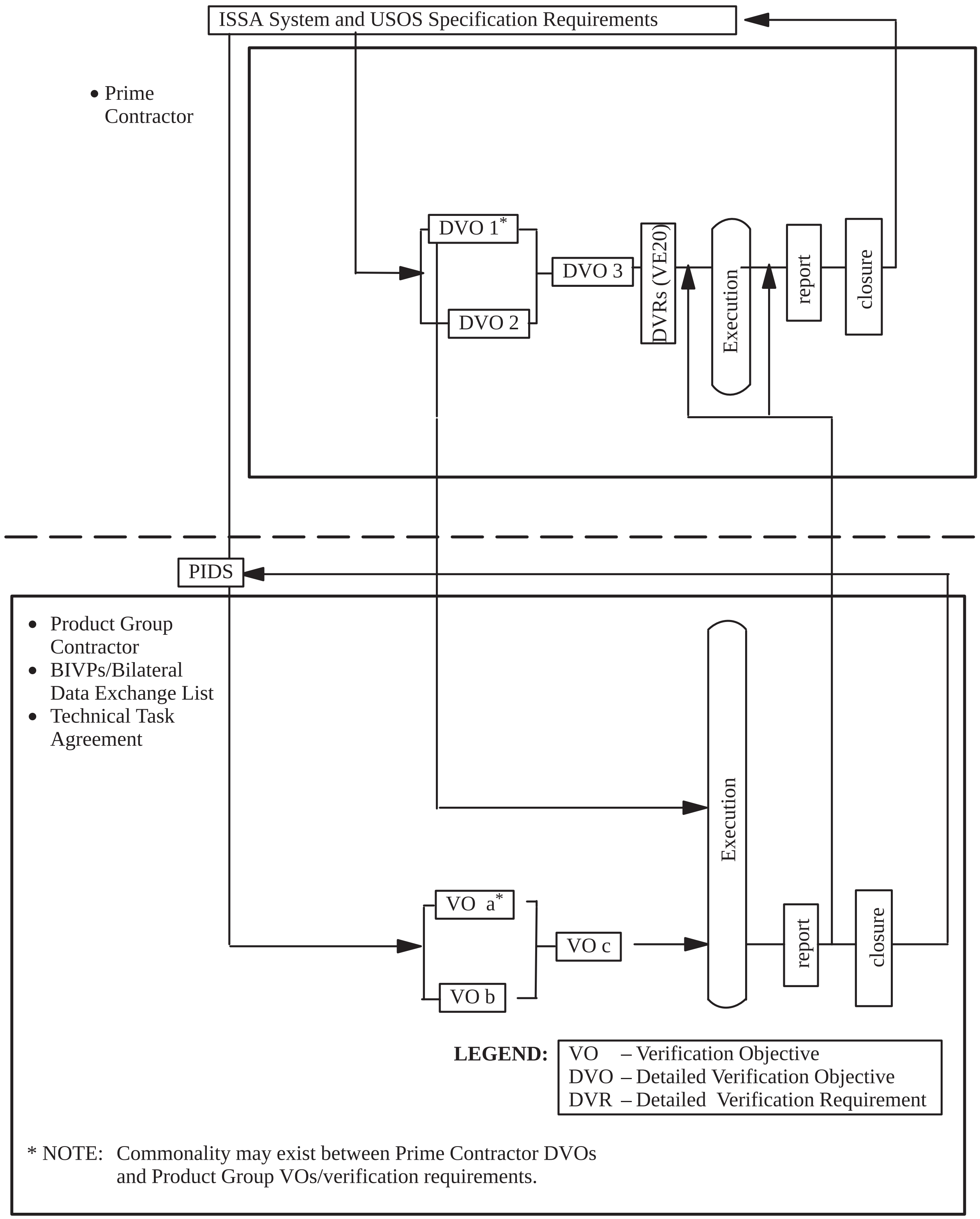


FIGURE 6–2 ALLOCATION OF VERIFICATION ACTIVITIES

activities. These activities encompass material selection, design tolerance verification, and identification of operational characteristics. These tests are usually performed by the engineering organization. Although hardware and software development testing and analyses are primarily concerned with preliminary design evaluation and data gathering activities that support the design process, they also provide the engineering data base necessary to establish confidence that the hardware and software will meet specification requirements, and that the manufacturing process will produce an acceptable product. The data acquired will also be used to establish processes, procedures, and test levels to support subsequent design, production, verification, maintenance, and checkout. Development testing may include the following:

a. Standard laboratory testing to support material selection

b. Component, breadboard, and subsystem testing to identify the failure modes and effects of environments and combination of design tolerances on performance

c. Tests that acquire data from integrated subsystem and system levels to identify operational characteristics and to develop ground and flight operational procedures

d. Initial electromagnetic compatibility (EMC) testing may be performed on components and Tier 1 subsystems to support hardware design and installation selection

Development tests need not be subjected to the rigors and controls associated with qualification, acceptance, and checkout programs unless the results are also intended to be used for qualification of hardware and software. In cases where development test results are to be used for qualification, this intent will be predeclared so the necessary approvals, controls, and procedures can be established with sufficient time to validate the entire test process for certification purposes. Development tests used for qualification will be monitored by Quality Assurance and will be conducted, controlled and documented in accordance with the same stringent requirements that are applicable to a qualification test.

6.2.2 ENGINEERING DEVELOPMENT TEST ACTIVITIES

a. Components – Hardware development testing or software prototyping at the component or unit level may be performed where analysis does not provide adequate assurance to the developer that his candidate design will meet specification requirements.

b. Subsystems – Subsystem engineering evaluation tests, e.g., design tolerances, interface compatibility and failure modes and effects, that are required to ensure that the candidate subsystem design is adequate, will be conducted as the developer deems necessary.

c. Functions – Although the majority of functional development testing may be performed at subsystem levels and below, with system level evaluations being performed by analysis, there may be occasions where this method does not give the developer adequate confidence in the functionality of a proposed design. In such cases partial system or system level development testing may be performed.

d. Integrated End Item – Development testing, where deemed necessary by the developer at the integrated end item level or multi–end–item level, will be limited to that which cannot be cost effectively accomplished at lower levels. Integrated end item level and multi–end–item level development test data may be used to support subsequent verification and checkout objectives where practical.

e. Software – There are four main levels at which software testing will be performed: (1) Unit, (2) Computer Software Component (CSC) integration, (3) CSCI integration, and (4) a system and segment level. In general, testing at the Unit and CSC integration levels is performed by the software design function. Details associated with the development process and how it relates to Unit and CSC integration is contained in the Software Development Plan (SDP), D684–10017–1.

f. Hardware and Software Integration – During the development phase, hardware–software integration (HSI) integrates non–qualified hardware such as engineering development models with software or firmware. The software or firmware may include special test software, prototype software, engineering versions of flight software, or even final flight software. Development phase HSI also includes the computer modeling type activities which supports (Engineering Development Model (EDM) development and system end–to–end integration. The development phase HSI demonstrates readiness for qualification phase HSI.

6.2.3 RELATIONSHIP TO OTHER VERIFICATION ACTIVITIES

Various development activities serve as a tool for guiding in the preparation of the qualification and acceptance process. Development testing and associated data utilized in the generation and evolution of models need not be subject to the rigors and controls associated with qualification, acceptance and checkout programs unless they are predeclared activities in support of qualification.. Also, other activities, such as Neutral Buoyancy Simulations, are utilized in the support of analysis activities (model validation, proof of concept, etc.). Those development activities required to closeout a qualification requirement will be predeclared, as discussed in section 6.2.5, and become part of the formal verification process.

6.2.4 MODELS

Models are engineering representations that imitate or emulate a function or environment. They may be used to support design proof–of–concept activities and formal verification activities, when used for specification compliance. In the latter case, fidelity of the model must be adequate for the level of specified verification. The Product Group contractors, IPs, NASA Institutions, and the Prime Contractor will maintain their models under configuration control and will authenticate them for their intended use. The following sections address general ISSA programmatic guidelines for model development and authentication. (Note: Models used to support formal verification compliance, which vary from these guidelines, must be reviewed and approved by the IT&V AIT). Configuration control of models is defined by each PG, NASA, IP and Prime configuration control plans.

IP models are authenticated by the IP, and are considered GFE unless otherwise stated at the time of delivery or modified by the Prime after delivery.

6.2.4.1 MODEL DEVELOPMENT

Data taken during development activities may be used in the generation and evolution of models. Development of models used to conduct analyses in support of specification compliance may require data from tests. This data requirement will be defined by DVOs (or the PG Contractor equivalent) developed in Step #2 of the Five-step process. These type of models are known as reference, or specification compliance models. On–orbit data will be obtained for use in updating and validating the models for subsequent use. The systematic techniques to develop models are shown in Figure 6–3 and general guidelines are described below.

a. Acceptable inputs and boundary condition data includes:

    1 Drawings (and other descriptive material which define the hardware to be analyzed)

    2 Test data from similar space hardware (with emphasis on geometry, test environment, and material properties)

    3 Engineering assumptions and physical/model groundrules

b. The creation of an analytical model, which depicts the flight article, test article, or the environment may use tools which have been previously certified and validated for this use (i.e. NASTRAN Model).

c. Proposed Analytical model results are correlated with test data and other known standards.

This process is iterated until the design is verified to meet design requirements.

Once defined, the models used to support specification compliance will be documented to provide additional traceability between models and analyses. The documented models are to be maintained under configuration control. Models used for verification will be described (along with their validation process) in Prime’s DR VE 23.

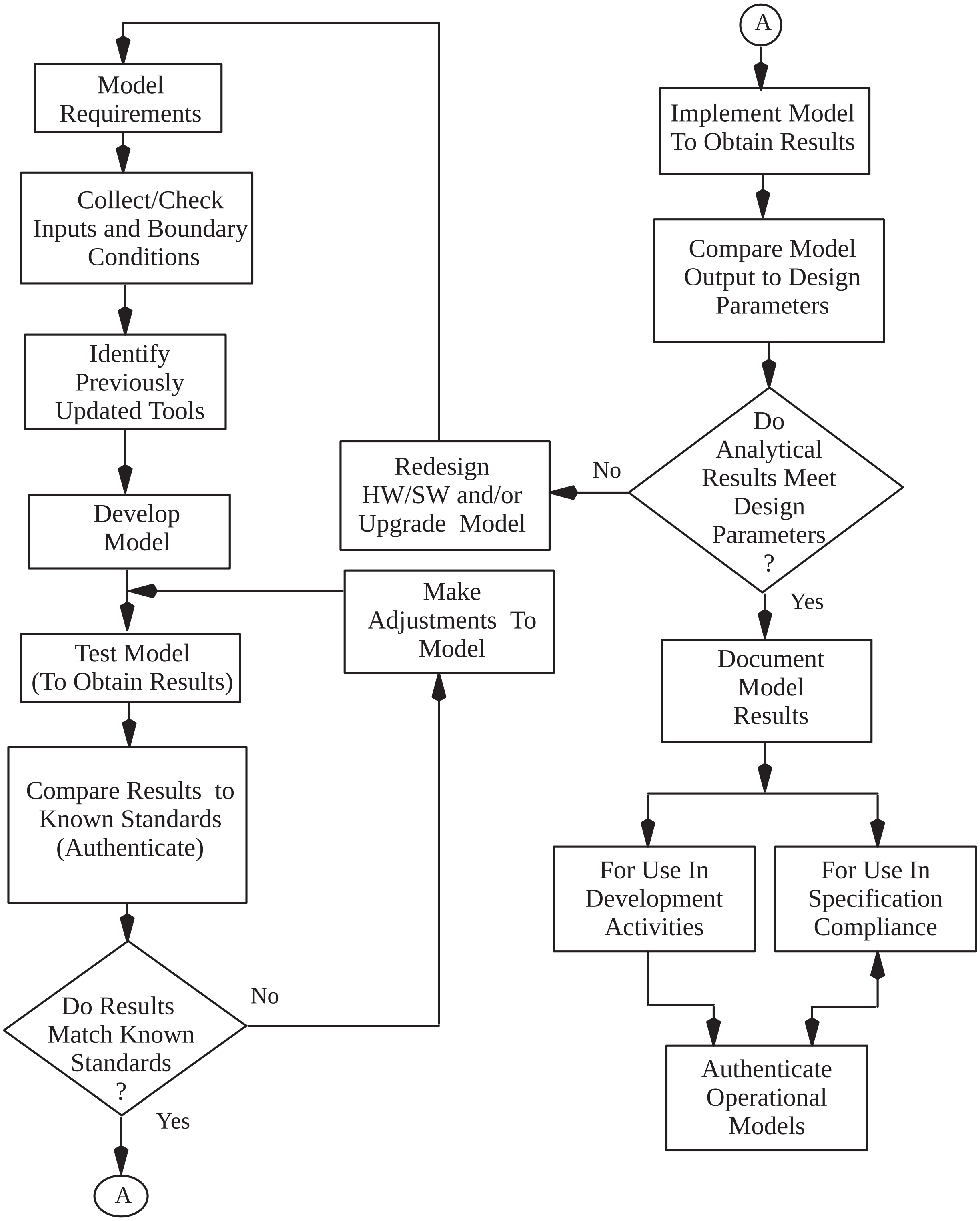


FIGURE 6–3 ANALYTICAL MODEL DEVELOPMENT

6.2.4.2 MODEL AUTHENTICATION

Model authentication is the process that validates the models used in development activities, specification compliance, and operational model usage. Authentication of models is conducted individually, since each model is uniquely related to the hardware or environment it represents, and is accomplished through use of the model. Two general guidelines for model authentication include:

a. Comparison with test data – Models are used to make pretest predictions. Actual test results are compared with these predictions to provide a basis for model confirmation or update. In some cases, test data or on–orbit performance data may be required as model inputs in order to properly represent the system.

b. Independent Confirmation – Model results are compared with independent analyses performed for the same conditions, inputs and ground rules. Examples include comparisons with results from other computer codes, or from hand calculations.

Model authentication by the PGs will be as described in their individual MVP's.

6.2.5 DEVELOPMENT TESTS SUPPORTING QUALIFICATION

The intent to use a test for qualification is required to be declared prior to test conduct and the approach is approved by the Prime Contractor (via a letter of intent or by inclusion in the PG's MVP). The Prime IT&V AIT will participate with the Product Group Contractor in development of test planning for pre-declaration. Any deviation will be formally documented and tracked until closed or waived.

Qualification requirements may be satisfied during development testing in those cases where the following criteria are met:

a. The article under development testing is done using the production configuration or where differences are allowed by the Prime Contractor/NASA.

b. Functional test required on the article under test prior to pre-declaration portion of test.

c. Test facilities must be certified by the provider and confirmed by the using organization to be adequate to support the desired test

d. To the extent that they would be required during formal qualification activities, quality assurance inspections of the test facility, the test article and the test procedure must be conducted and formally documented.

e. The verification requirement and associated pass/fail criteria must be formally documented and approved by the Prime Contractor.

f. Test results will be documented in a report and available by the Data Accession List to the NASA/Prime IT&V team.

6.3 FLIGHT ARTICLE QUALIFICATION ACTIVITIES

Prior to subjecting flight items to actual use, it is mandatory that the article is qualified to show it is capable of meeting the design and performance requirements to which it was built. Qualification activities comprise those that demonstrate and formally document that the design, development and production processes generate products that meet specification requirements in specified life–cycle environments. Qualification will be based on the full range of design requirements documented in the product Type A&B level specifications and will be accomplished by the means defined in section 4, Quality Assurance Provisions, of those specifications. Environmental limits, environmental exposure time and cycles will be specified by each user of components to each supplier of components.

The verification methods used in qualification include analysis, inspection, demonstration and test. An exception to this is the use of similar equipment design qualification. In this case the method is called qualification by similarity, wherein the design of the item is qualified in some respect by comparing its design to the design of an item whose design has been previously qualified.

6.3.1 QUALIFICATION ARTICLES AND CONFIGURATION

Qualification by demonstration and test is divided into two major subsets, structural and functional. Two classes of test articles are used: (1) structural test articles for structural specification compliance testing, and (2) flight articles dedicated to test for functional performance specification compliance. Demonstration and test is divided into two major subsets; structural and functional. Two classes of test articles are used: (1) structural test articles for structural specification compliance testing, and (2) flight articles dedicated to test for functional performance specification compliance.

a. Test Article – Qualification test (or demonstration) hardware and software will be of the same configuration and manufacturer, and be manufactured under the same production processes as the flight hardware and software, unless variances are approved formally by the Prime Contractor and NASA and adequately documented according to the test article supplier’s established configuration management procedures. The use of dedicated test articles will ensure that the cumulative effects of the environments and operations are measured. Where feasible, hardware used for earlier levels of qualification will be modified and refurbished for use during the increments of integrated hardware qualification. However, additional hardware resources will be provided as required, both to achieve the required levels of system end–to–end single string and/or redundant capability for systems qualification and to replace hardware which is incapable of refurbishment to acceptable standards of fit, form and function.

Subassemblies required to complete higher level assemblies for qualification activities:

a. Will be flight quality and configuration hardware, except they may contain Grade 2 parts as defined in MIL–STD–975, NASA Standard Electrical, Electronic, and Electro–mechanical (EEE) Parts Lists and subassembly connectors that interface with protoflight hardware will be flight quality

b. May be qualified separately and on a schedule independent of the higher level assembly qualification

c. Will be ultimately qualified and notification of qualification approval will be provided to the user of the subassembly by the supplier along with any changes, deviations, and/or waivers incurred during qualification

6.3.1.1 APPLICATION BY TEST

The qualification test program will consist of the selective application of various types of tests for components, assemblies, and subsystems. These tests may include, but not be limited to, tests such as leakage, pressure, environmental, human factors, acoustics, shock, thermal cycling, thermal vacuum, structural, random vibration, life and reliability, redundancy management, fluid compatibility, Electromagnetic Interference and Electromagnetic Compatibility (EMI/EMC), and performance and functional tests.

Qualification tests will be conducted in accordance with SSP 41172, ISSA Program Qualification and Acceptance Environmental Test Requirements. Qualification tests will demonstrate that the product can meet design and performance requirements under the most severe and life–cycle environmental conditions, experienced during operating and non–operating conditions. Qualification for an operating mode includes only those environments that are specified in the design requirements. Qualification test hardware and software will be of the same configuration and manufacturer as the flight hardware and software (e.g., it will be manufactured using flight quality and configuration materials and parts under the same production process as the flight hardware and software). Any deviations from this will be documented and the required delta–verification will be performed later as part of the H/W and S/W acceptance activities. Deviations will be tracked until closed or waived. In general, tests will be conducted on dedicated test articles, however, the protoflight concept may be employed where associated risks are determined to be acceptable. Master tools, DTAs, simulators, simulations and models used to represent interfaces will be certified by the provider. Simulators and simulations will be certified as described in each PG Software Development Plan (SDP).

6.3.1.2 PREQUALIFICATION AND POST QUALIFICATION ACCEPTANCE

Test hardware and software component, assembly, or subsystem qualification test articles will be required to pass functional or environmental pre–qualification acceptance tests prior to or in conjunction with qualification tests to confirm adequacy and to establish a nominal performance baseline. Following completion of the qualification testing (except static load test), a post qualification functional test will be performed. Comparison of that data to the pre–qualification test data will be done to confirm that operation at the extreme environmental limits during the qualification test did not cause damage to the test article. Those components requiring post test disassembly to uncover incipient failure modes and latent defects will be identified and documented in applicable qualification plans.

6.3.1.3 PROTOFLIGHT APPROACH

It may be acceptable, in certain circumstances, to perform qualification testing on actual flight hardware in lieu of a dedicated test article. This approach includes the use of reduced test levels or durations as defined in the Program Qualification and Acceptance Environmental Test Requirements document (SSP 41172) and post test hardware refurbishment, where required, to allow the tested hardware to be subsequently used for flight. Subsequent assemblies will be subjected to protoflight test levels.

The protoflight test approach carries increased risk with its use; therefore, upon initiation of the protoflight test program, the assembly test sequence will be reviewed and a judgment made as to whether the article will be acceptable for flight. Upon completion of the protoflight test program, the assembly test history will be reviewed. If there were deviations from the original test plan an additional judgment must be made as to whether the article will be acceptable for flight or if refurbishment will be required. In order to coordinate with, and gain NASA/Prime approval, the Product Groups will document any planned use of the protoflight approach in their Master Verification Plans. Flight element acceptance tests and qualification tests may be combined into a single test.

The components installed in this flight element will be qualified to protoflight or qualification levels, as applicable, and will be acceptance tested.

6.3.1.4 QUALIFICATION OF MATURE DESIGNS

Off–the–shelf hardware and software will be qualified. Previous qualification may be sufficient. Additional qualification will be performed where predicted environments are more severe than previous qualification levels, where previous qualification did not include all predicted environments, or where modifications have been made to the hardware that would negate previous qualification.

6.3.2 TEST ACTIVITIES DOCUMENTATION FLOW

The comprehensive verification program developed and implemented by all the Product Groups will be documented and reported through the PVIS. To control the development of the verification documentation, the conduct of test and demonstration verifications and the resultant verification reports, teams will be established at the Product Groups. These teams will follow similar paths and implement similar tasks for the accomplishment of these tests and demonstrations. Figure 6–4 depicts a typical documentation flow that the Product Groups will follow in the preparation, conduct and release of documentation to support the Prime Contractor verification activities. This flow is for the Product Group end item qualification and acceptance test and demonstration activities flow. It will also be used for Prime Contractor verification activities. (Actual setback times may vary between Product Group Contractors).

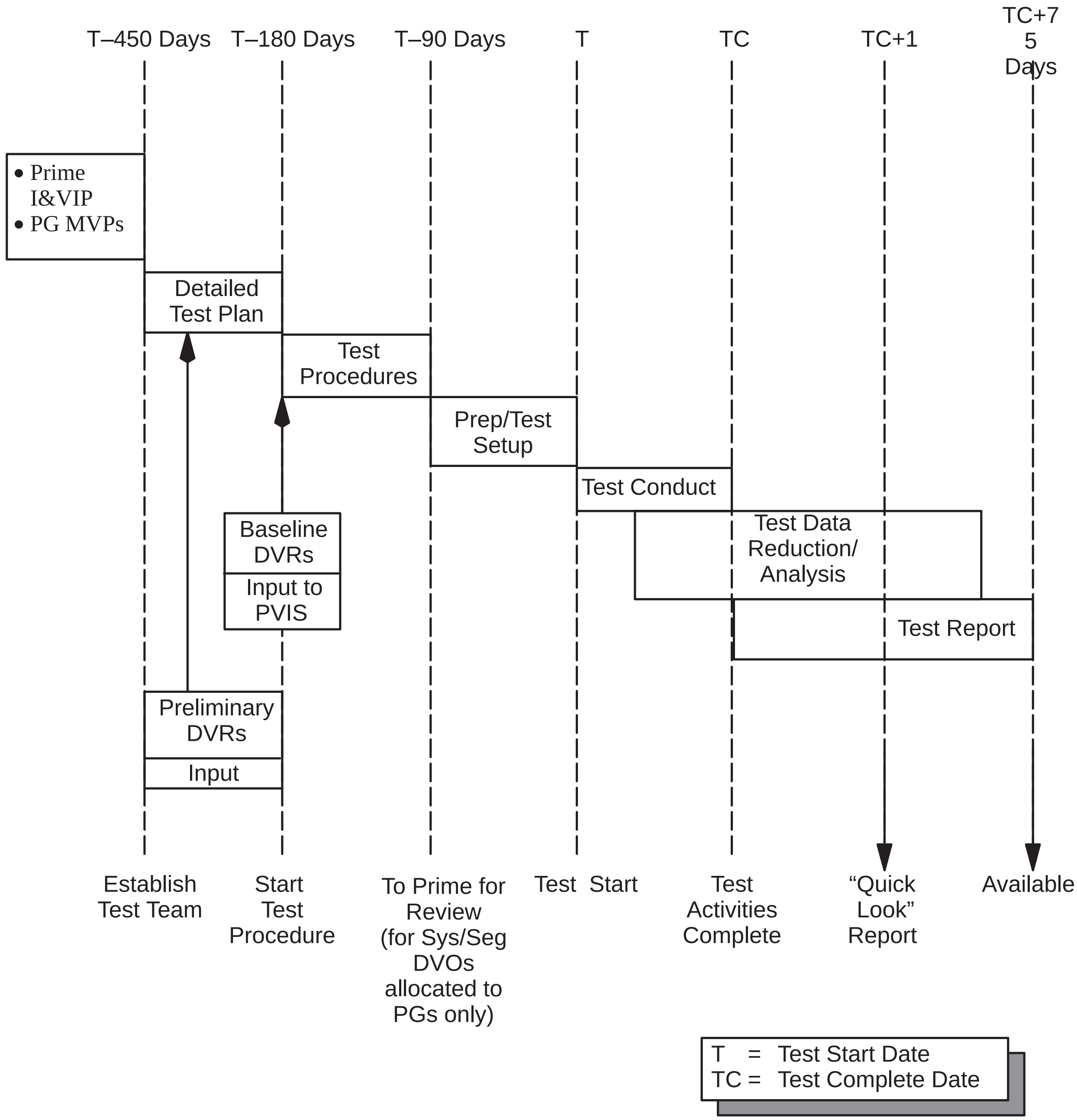


FIGURE 6–4 TYPICAL TEST AND DEMONSTRATION DOCUMENTATION FLOW

6.3.3 PRIME CONTRACTOR QUALIFICATION

The Prime Contractor is responsible for qualification of the U.S. On–orbit segment, and the ensuing successful integration of the U.S. On–orbit segment with other segments. Figure 6–5, Hardware and Software Integration and Qualification Flow Process, shows the typical hardware and software integration and verification flow beginning with Product Group hardware and software development and ending with launch package integration.

The Prime Contractor qualification program relies heavily on end item level verification conducted by the Product Groups and system and segment–level verification delegated by the Prime Contractor to the Product Group. Requirements implemented in hardware and software residing in multiple end items are candidates for performance of verification by the Product Groups.

The Prime Contractor qualification program relies heavily on data gathered during Product Group qualification activities. Such activities include those performed to qualify System or Segment level functions performed (all or in part) by the Product Groups.

6.3.4 PRODUCT GROUP QUALIFICATION

The Product Group's qualification programs are based on a building block approach beginning with Hardware Configuration Item (HWCI) and Computer Software Configuration Item (CSCI) qualification and progressing on to end item qualification and Prime Contractor System and Segment qualification. Each Product Group will generate a Master Verification Plan (MVP) defining his verification and qualification program.

a. Software Qualification – Formal Qualification Testing (FQT) is performed on all deliverable software at the CSCI level in accordance with DOD–STD–2167A, Defense System Software Development, as tailored per D684–10017–1, Prime Contractor Software Development Plan (SDP). FQT confirms the software's capability to meet the allocated design requirements per section 4 of each CSCI Software Requirements Specification. Tests are documented in Software Test Plans (STPs). Test results are recorded in Software Test Reports (STRs). CSCI qualification is formally closed by a FCA and PCA. Although Commercial Off–The–Shelf (COTS) products are not required in themselves to be formally qualified, integration of those COTS products with other products, including other COTS products do require FQT as stated above. For further information on software FQT, refer to the Prime Contractor SDP, section 5.0.

b. Component and Subassembly Qualification – Hardware qualification occurs at the HWCI and critical item levels. Firmware resident in a HWCI is considered part of HWCI and will be included in the hardware qualification. Qualification also demonstrates that adequate design and safety margins have been incorporated into the products. The hardware item being qualified may be subjected to both natural and induced environments and the performance parameters evaluated over the full range of Space Station operational conditions. Detailed verification objectives, plans, and procedures are generated for hardware qualification and an evaluation of the results including test data are provided in appropriate reports. Hardware Configuration items and Critical Items which are also considered end items are qualified and delivered subject to formal PCA.

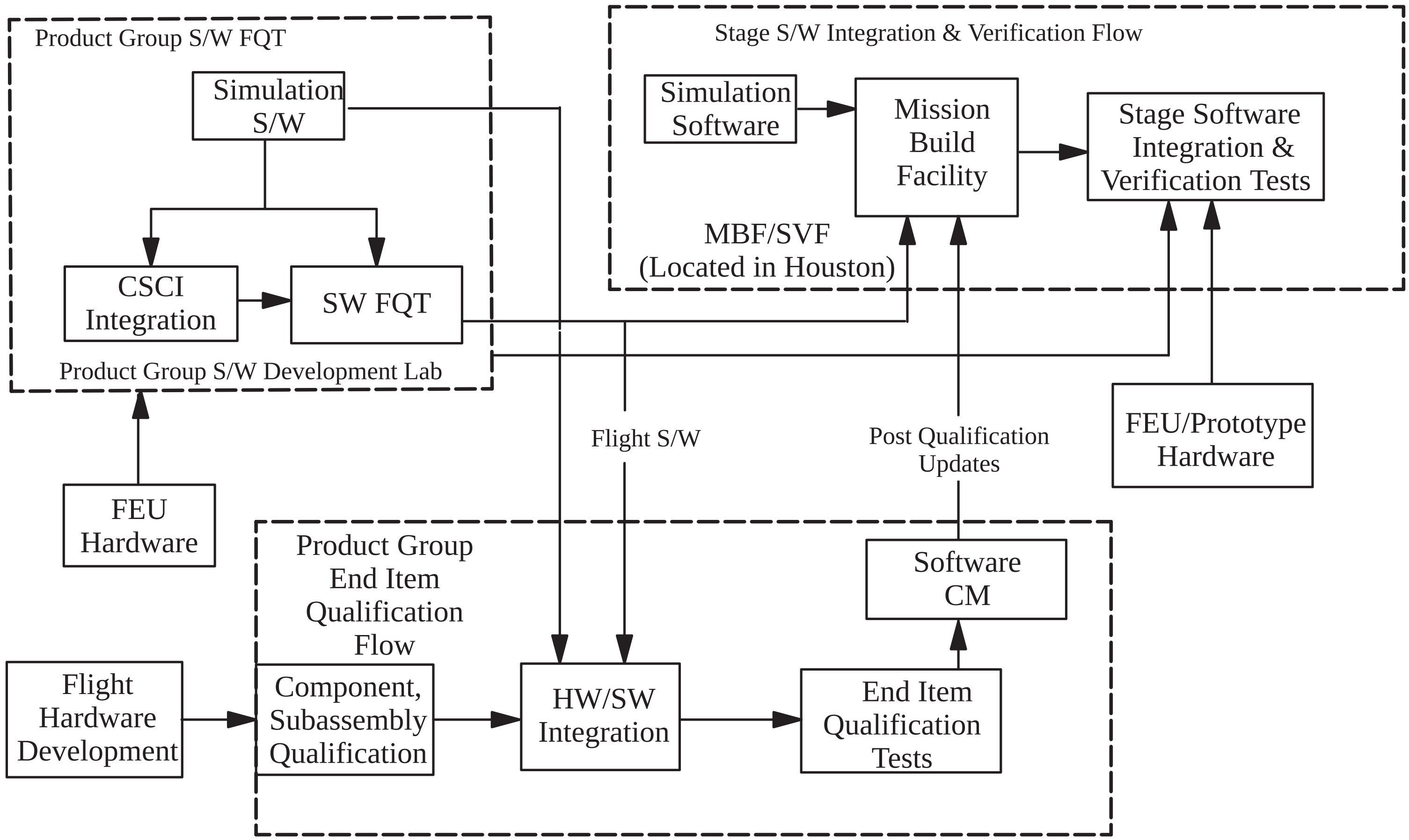


FIGURE 6–5 HARDWARE AND SOFTWARE INTEGRATION AND QUALIFICATION FLOW PROCESS

c. End Item Qualification – follows integration of flight hardware and associated flight software. Hardware and software integration tests and analyses will be performed to confirm that the resulting system performs as expected.

d. End item qualification must be completed prior to conclusion of, but may be conducted concurrently with, flight article acceptance. End item qualification includes verification of the complete function and performance allocated to the end item in conjunction with the associated flight software. The flight software associated with an end item may or may not reside in the end item hardware. Detailed verification requirements, detailed verification plans, procedures, verification reports, verification closure documentation, and compliance reports are generated for each end item.

e. Product Group to Product Group Responsibility – Product Groups on contract to deliver end items comprised of hardware or software provided by other Product Groups are responsible for complete verification of the integrated end item.

f. The end item integrator may also be responsible for test and verification to close specific System and Segment DVOs. This responsibility, assigned via funded task order from the Prime Contractor, may include additional tests, and analysis of verification data provided by other PGs not associated with a given end item.

g. The Product Group responsible for the integrated end item provides to the hardware or software supplier: (1) interface requirements, and (2) results of end item verification activities, as required, to support completion of the supplier's hardware or software qualification.

h. The Product Group responsible for hardware or software used in another PG's end item provides to the end item integrator: (1) proposed verification requirements and procedures, and (2) comments to end item verification plans and procedures, (3) On-site support, where appropriate, for implementation of end item qualification and acceptance test programs.

i. If so tasked and funded by the Prime Contractor, Product Groups also participate in the development of verification requirements, plans and procedures to verify System and Segment DVOs that would be performed by another Product Group.

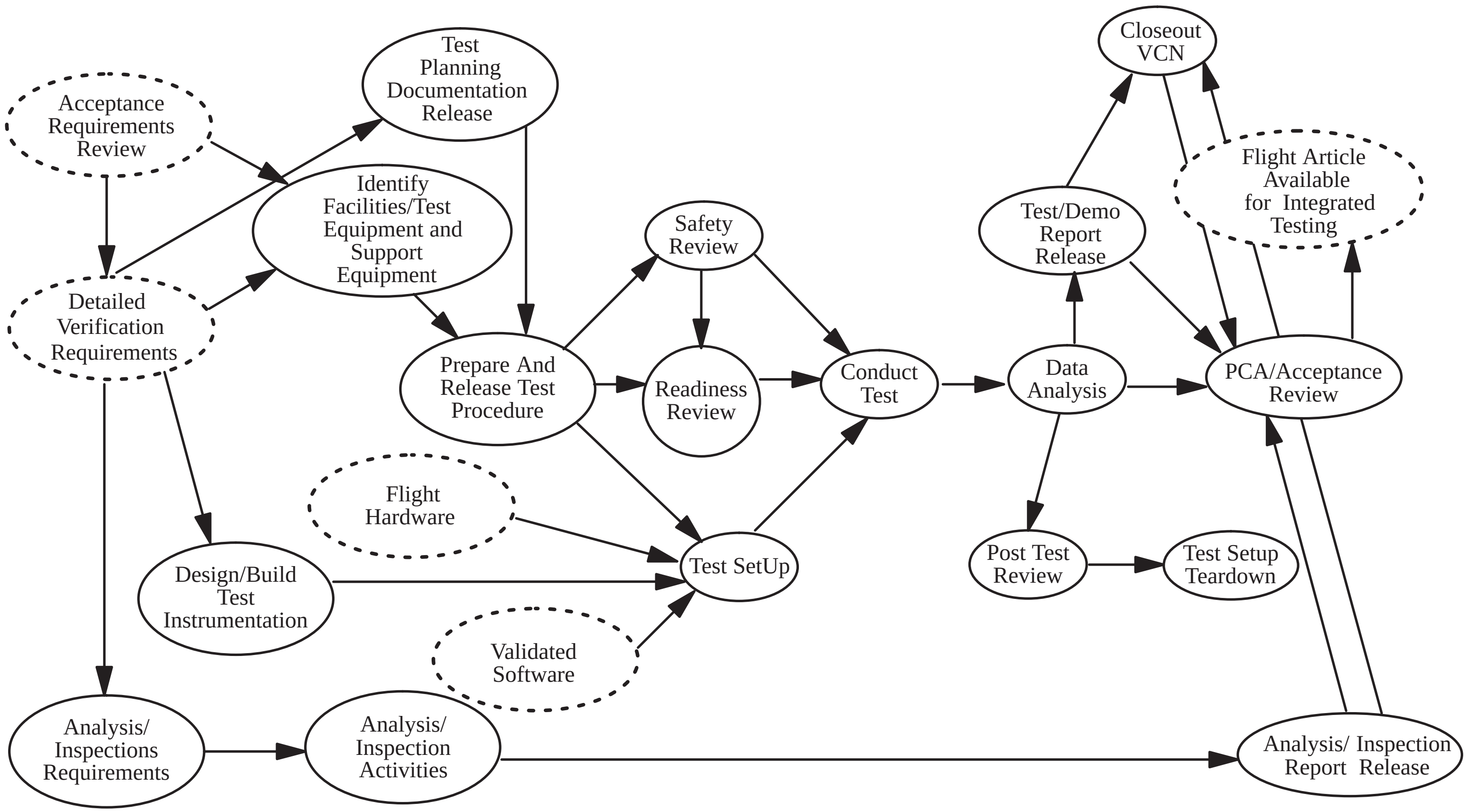


FIGURE 6–6 END ITEM ACCEPTANCE PROCESS

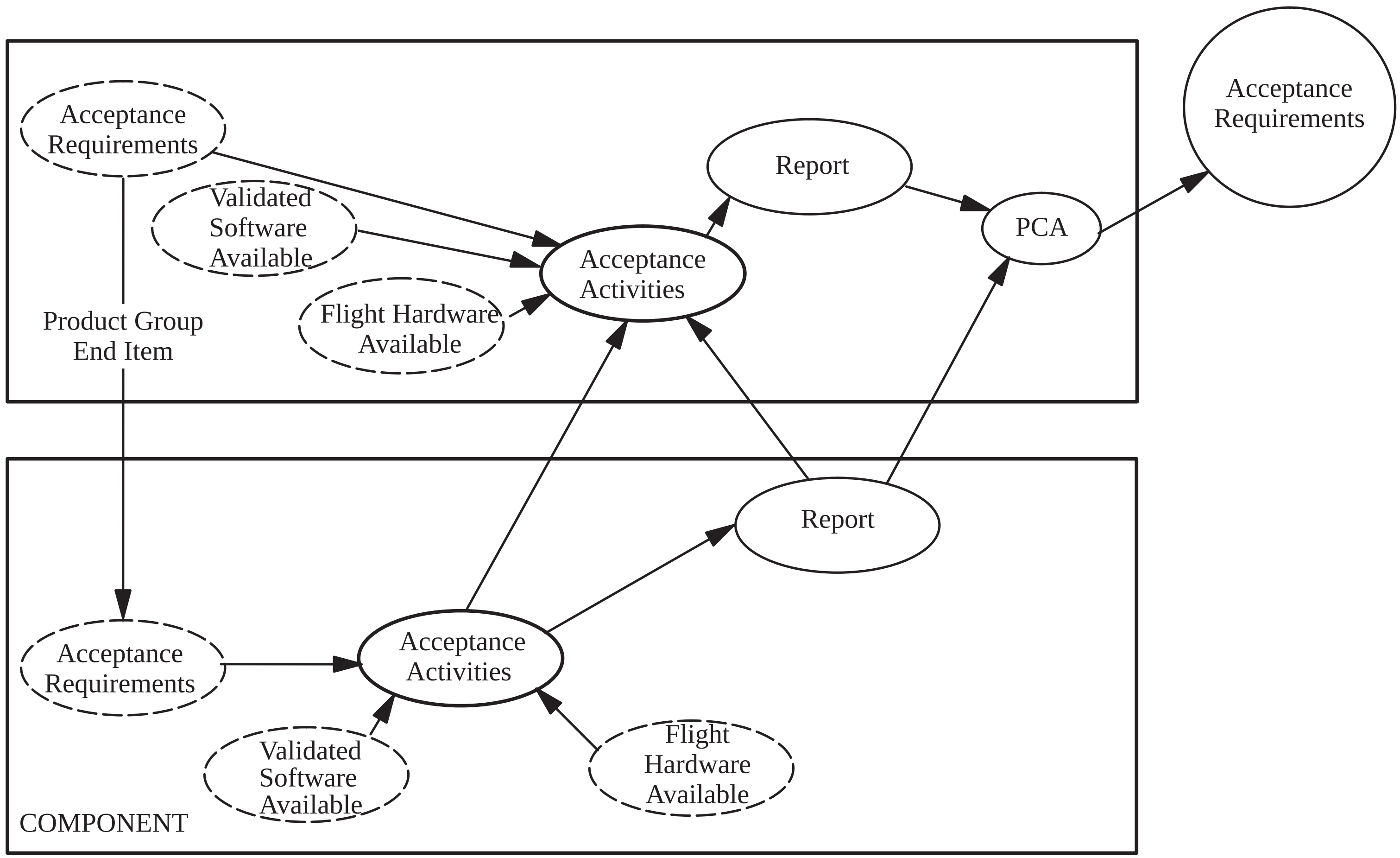


FIGURE 6–7   ACCEPTANCE ACTIVITIES

6.3.5 ANALYSES

Verification analyses will be performed as indicated in the associated section 4 within each specification. For those requirements to be verified by analysis, a DVR will be produced which will summarize the analysis objectives, success criteria, data requirements, and analysis approach. DVRs will serve as the basis for a verification by analysis plan which will relate the analyses to the DVRs and the associated requirements being verified. The plan will describe the planned analysis methods to be used and will tie the analysis to a schedule.

The analysis planning information is contained in two places for the Prime:

a. The Master Analysis Plan and schedule

b. DR VE 23

The verification analyses will be performed as part of the DAC for the Prime.

Results from completed analyses will be documented as a part of a series of verification assessment reports which comprise the contract deliverable documentation. The report will correlate the analysis assessment to the source of the requirement and describe analysis results. Results will be described by analytical data, listings, and plots.

Although verification analyses are aimed at providing closure of specific requirements, analyses tend to be discipline oriented.

6.3.6 INSPECTION

Inspections performed by the Prime will be identified on DVRs. After the inspections are performed, a memo will be generated by the organization performing the inspections stating the results of the inspections. Inspection plans for the Prime will not be generated.

6.4 FLIGHT ARTICLE ACCEPTANCE ACTIVITIES

The Space Station acceptance program is conducted on flight hardware and software to assure that the deliverable flight item was manufactured as designed and is free from manufacturing and workmanship defects. The acceptance process will rely heavily on the tests and demonstrations conducted at the Space Station Product Groups and the results integrated at the Prime Contractor level to ensure that the overall Space Station vehicle meets its acceptance requirements. The acceptance process also applies to the Flight Support Equipment (FSE) and Orbital Support Equipment (OSE). The process for acceptance of Ground Support Equipment (GSE) and Test Support Equipment (TSE) is defined in Section 8.0 of this document.

The Product Group’s acceptance program will occur in the building block approach, beginning with components, and progressing into assemblies/racks, subsystems, and end item testing conducted on the flight articles. These test build from the rigorous acceptance of structures, components, assemblies, and Orbital Replaceable Units (ORUs). The acceptance test program is conducted per the requirements detailed in SSP 41172, Qualification and Acceptance Environmental Test Requirements Document. Qualification Activities may overlap Acceptance Activities.

The tests will be conducted with test procedures generated, reviewed and approved by the integrated product team. The test/demonstration procedures and the verification reports for the delivered end items will be approved by the integrated product teams prior to use on the acceptance activities. The acceptance process will conclude with an FCA/PCA conducted at the Product Group facility as part of the delivery process of the end items to the Prime Contractor. The process can be combined with the Prime Contractor's FCA/PCA. This process will be enhanced and details will be added as the program matures. Figure 6–6, End Item Acceptance Process, provides an overview of the end item acceptance process.

Acceptance test detect deficiencies in workmanship, material, and quality. Nondestructive test verification methods and procedures shall be established to support the acceptance test program. Ac acceptance team, composed of representatives from NASA, the Prime Contractor, and the Product Groups, will review and ensure the overall completeness and acceptability of data acquired before any end item is delivered to NASA. The delivery of the end items will be accomplished through the FCA/PCA process documented in the Space Station Program Configuration Management Plan (D684–10097–1). Control and certification of the acceptance review process is an integral part of the quality assurance program per SSP 41173 Space Station Quality Assurance Requirements.

The production acceptance tests use procedures facilities, and support equipment acquired and certified during the development and qualification test phase.

Acceptance testing will be documented in accordance with the Delivery Plan document(s) developed by Product Assurance. The minimum mandatory environmental acceptance tests and their required levels, and duration are also defined in SSP 41172. The Product Groups shall develop and implement a disciplined approach to acceptance testing including the documentation of acceptance requirements and test procedures. The acceptance requirements and test procedures shall be based on the qualification test procedures, as well as SSP 41172.

Each Product Group will deliver an Acceptance Data Package (ADP) at end item acceptance, and the ADP will reference the acceptance requirement document number. Acceptance requirements will be documented in the Product Group's internally defined format. All verification activities performed for the purpose of acceptance will be performed to the approved requirements and procedures. All results and conclusions resulting from acceptance will be documented in reports made available to the Prime Contractor by the Product Group and to NASA by the Prime Contractor on an "As Requested" basis, per the Data Accession List.

6.4.1 ACCEPTANCE REVIEW

The Space Station program will conduct acceptance reviews starting at the Product Group facilities with hardware accepted by the Product Group. This hardware is then integrated into major assemblies and end items and an acceptance review is conducted to deliver these end items to the Prime Contractor. Figure 6–7 Acceptance Activities, provides an overview of the acceptance activities for the Internal Space Station program.

The Acceptance Review will be conducted to assess the status of the hardware, software, and acceptance data package deliverables. The ADP will be submitted per the requirements of DR PC08, Acceptance Data Package, for the Prime deliveries to NASA. The Product Group will submit their ADP per Supplier Data Sheet SS–PC–008 to the Prime Contractor. The acceptance requirements and acceptance test procedures shall be referenced as part of the Acceptance Data Package, in accordance with the requirements of SSP 30695, Acceptance Data Package Requirements Specification. All waivers, deviations, ship short items and open work will be identified and the DD250 will be verified as complete.

To further ensure quality and integrity of the end items, the Prime Contractor will conduct in–house assessments of readiness to support the PCA for each end item article delivery. This is a coordinated assessment by Configuration Management, and Quality Assurance (QA), Systems Engineering and Integration (SE&I), and Systems Test functions. It consists of an assessment of the accumulated design, build, and test data for the flight article, with a planned management involvement and follow–up activity to resolve any issues.

6.4.2 FLIGHT SUPPORT EQUIPMENT/ORBITAL SUPPORT EQUIPMENT ACCEPTANCE

Verification of the Support Equipment is divided into two major categories; Ground Support Equipment/Test Support Equipment (GSE/TSE) and Orbital Support Equipment/Flight Support Equipment (OSE/FSE). The verification of GSE/TSE is covered in section 8 of this document. Verification of the FSE and OSE design, fabrication, and assembly processes will be accomplished in the same manner as for the element flight hardware. End item acceptance tests will be conducted to assure there are no deficiencies in workmanship, material, and quality. Acceptance will be nondestructive and, when environmental tests are required, they will be performed at levels commensurate with expected flight loads. Formal acceptance documentation will be initiated as applicable.

6.4.3 PRIME ACCEPTANCE SUPPORT APPROACH

The Prime Contractor’s acceptance program relies on the acceptance verification accomplished at the Product Groups (at the end–item level and for certain Prime Contractor delegated tasks). The Prime Contractor will perform software validation at the Software Verification Facility (SVF) to ensure the actual software build data files are acceptable and ready to support the new assembly configuration. All the requirements of the USOS (assembly) will be satisfied and verified prior to DD250 of that end item. Prior to delivery of an end item to NASA, the Prime Contractor and PG will ensure that:

a. End item acceptance process is complete for the Product Groups

b. All necessary ground testing has been completed

c. The software, and data files are valid and support the user’s needs

d. The On–orbit assembly process is defined and requirements and procedures for assembly have been provided to NASA for implementation for that end item and applicable stage (Operations IPT to provide)

An FCA/PCA of the end items will be conducted by the Prime Contractor prior to DD250 of the end items to NASA.

7.0 DEVELOP VERIFICATION REPORTS AND PREPARE CLOSURE DOCUMENTATION

Following the completion of Step 3, Verification Assessment Reports are prepared. Depending upon the results found in these reports when compared with the DVOs prepared in Step #2, Verification Closure Notices (VCNs) will be generated by the Prime Contractor to substantiate PVIS input. Closure documentation will be provided by PGs to the Prime Contractor for System and Segment requirement verification activities allocated to the PGs. After Verification Closure Notices are prepared, Specification Compliance Audits will be conducted for each assembly configuration. These efforts constitute Steps #4 and #5 of the Five–Step Verification Process, as shown in Figure 7–1, and are discussed in detail in the following paragraphs.

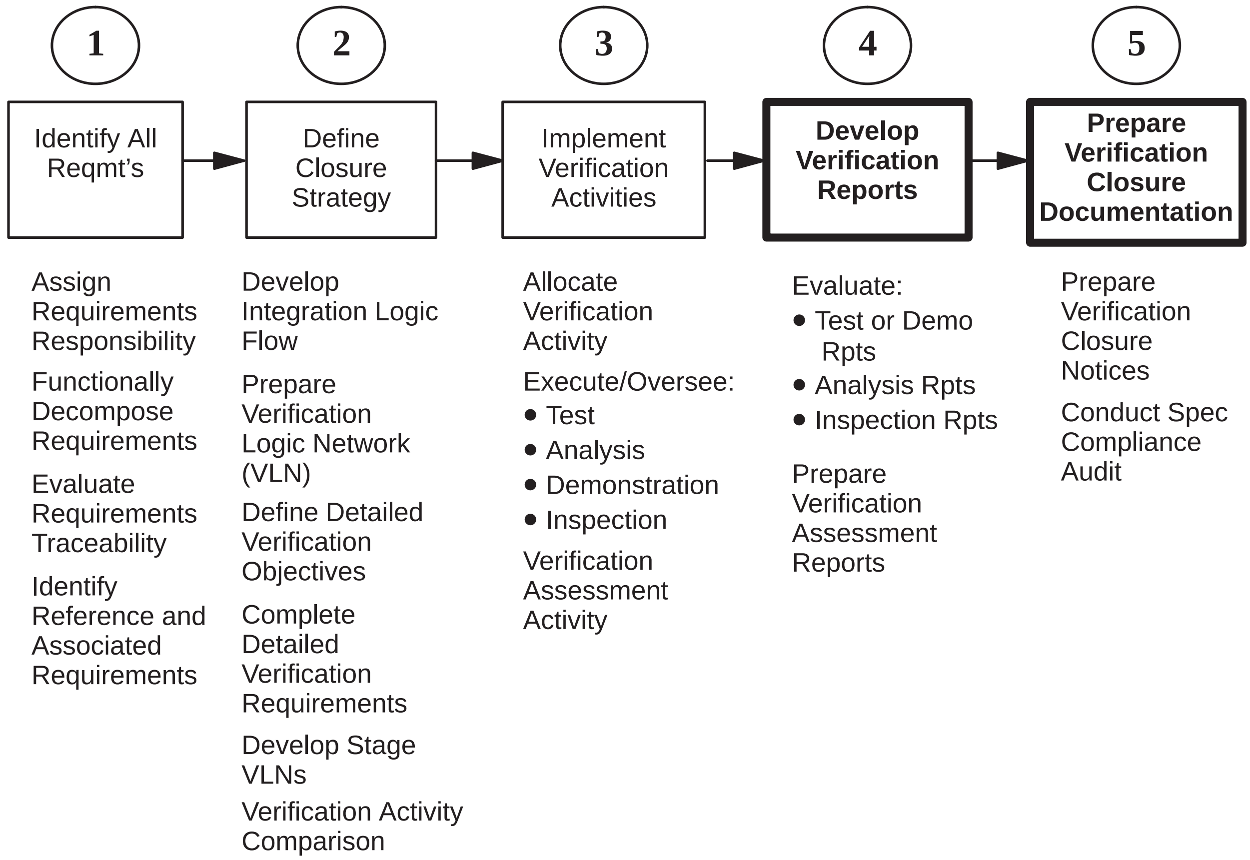


FIGURE 7–1 PRIME CONTRACTOR'S FIVE–STEP VERIFICATION PROCESS

7.1 DEVELOP VERIFICATION REPORTS

Reports addressing Step 3 results will be prepared by or provided to the Prime Contractor for evaluation to ensure verification is complete. These reports will include the analyses performed by the Vehicle Analysis Team (VAT) and reports from verification activities in the SVF. These reports will be reviewed by each verification subteam that is responsible for the acceptance of these results. Acceptable results will be used to close system and segment level requirements. Verification reports, prepared by the Verification Subteams, will compare the verification activity results against the DVO(s) that drove the activity. The verification reports, as discussed in Section 4.4, summarize the results, note any noncompliance, and recommend actions to either close the requirements, reverify, or issue waivers or deviations. The verification reports serve as backup data to the formal verification closure documentation discussed below. (Electronic access is the preferred means of obtaining the reports prepared by the Prime Contractor.)

The results of the Prime, IP, PG and LMSC verification assessments will include the following types of information:

a. Closure of applicable specification requirements through verification execution

b. Fidelity of the verification activity

c. Any model complexities

In addition to the analysis, inspection, demonstration and test reports, PG verification assessment and IP Process Sampling “quick-look” reports will be used as an input to the Verification Assessment Reports. For further description of verification reports, see section 4.4.3.

7.2 PREPARE VERIFICATION CLOSURE DOCUMENTATION

After each activity has been evaluated or reverified in Step #4, VCNs or equivalents will be prepared for each DVO. These notices are a part of the DVO form, as shown in Figure 7–2. For more information, see Section 4.4.

7.2.1 PRIME CONTRACTOR

VCNs will be approved by each Verification Subteam that was responsible for the original DVO development (this includes both the Prime and NASA). After approval, this data will be input into PVIS, showing that each requirement has been verified and closed. A PVIS audit will be conducted for each assembly configuration to ensure all activities are complete. PVIS reports, once generated, will be generated to support the Certification of Flight Readiness (CoFR) process. Specifically, a traceability and compliance report (DR VE–24) will be generated to document the Section 3 design requirements verification traceability flowdown from source to closure for the ISSA System specification within the capabilities of PVIS. The traceability and compliance can be reported by end item, or ISSA requirement. The flow of traceability and compliance reporting for the Prime Contractor, and its relation to the Verification Process is shown in Figure 7–3.

7.2.2 PRODUCT GROUPS, NASA INSTITUTIONS AND LMSC

To support verification closure documentation, the Product Group, NASA Institutions, and LMSC contractors will provide SS–VE–024 specification Traceability and Compliance Reports and Verification Completion Notices or equivalents as described in paragraph 4.4.3.

DETAILED VERIFICATION OBJECTIVE (DVO)

1. DOCUMENT ID:	***2. RQMT ID:***	***2. DVO #:***

4. RQMT PARA # (SEC 3):	***5. RQMT PARA TITLE (SEC 3):***
	6. PRIMARY VERIFICATION RESPONSIBILITY (SEC 3):

7. RQMT TEXT (SEC 3):

8. VERIFICATION RQMT TEXT (SEC 4):

9. ASSOCIATED RQMT PARA #(S):	***10. REFERENCE RQMT PARA #:***

11. DETAILED VERIFICATION OBJECTIVE TEXT/TITLE: ***METHOD:***

12. SUCCESS CRITERIA:

13. CONDITIONS:

14. PROGRAM MILESTONE CONSTRAINTS:					***15. PREREQUISITE DVO CONSTRAINTS:***
PDR	IDR	AR	ORR	OTHER	
CDR	FCA	PCA	FRR		

16. LEVEL OF IMPLEMENTATION:			***17. IMPLEMENTING ORGANIZATION:***					
ORU	LCH PKG	SEGMENT	PRIME	LP	PG 1	PG 2	PG 3	GND
END ITEM	STAGE	ISSA	ESA	CSA	RSA	NASDA	ASI	OTHER

18. UNIQUE RESOURCES NEEDED:	***19. CONFIGURATION: (VMDB ITEM P/N & NAME)***

20. DVO APPROVAL:

PRIME NASA

VERIFICATION COMPLETION NOTICE (VCN)

21. COMPLETION DOCUMENTS:	22. DVO STATUS:			
	BASELINED		DELETED	
	PROPOSED		VERIFIED	

23. VERIFICATION COMPLETION APPROVAL:

PRIME NASA DATE:

FIGURE 7–2 VERIFICATION COMPLETION NOTICE (DVO FORM)

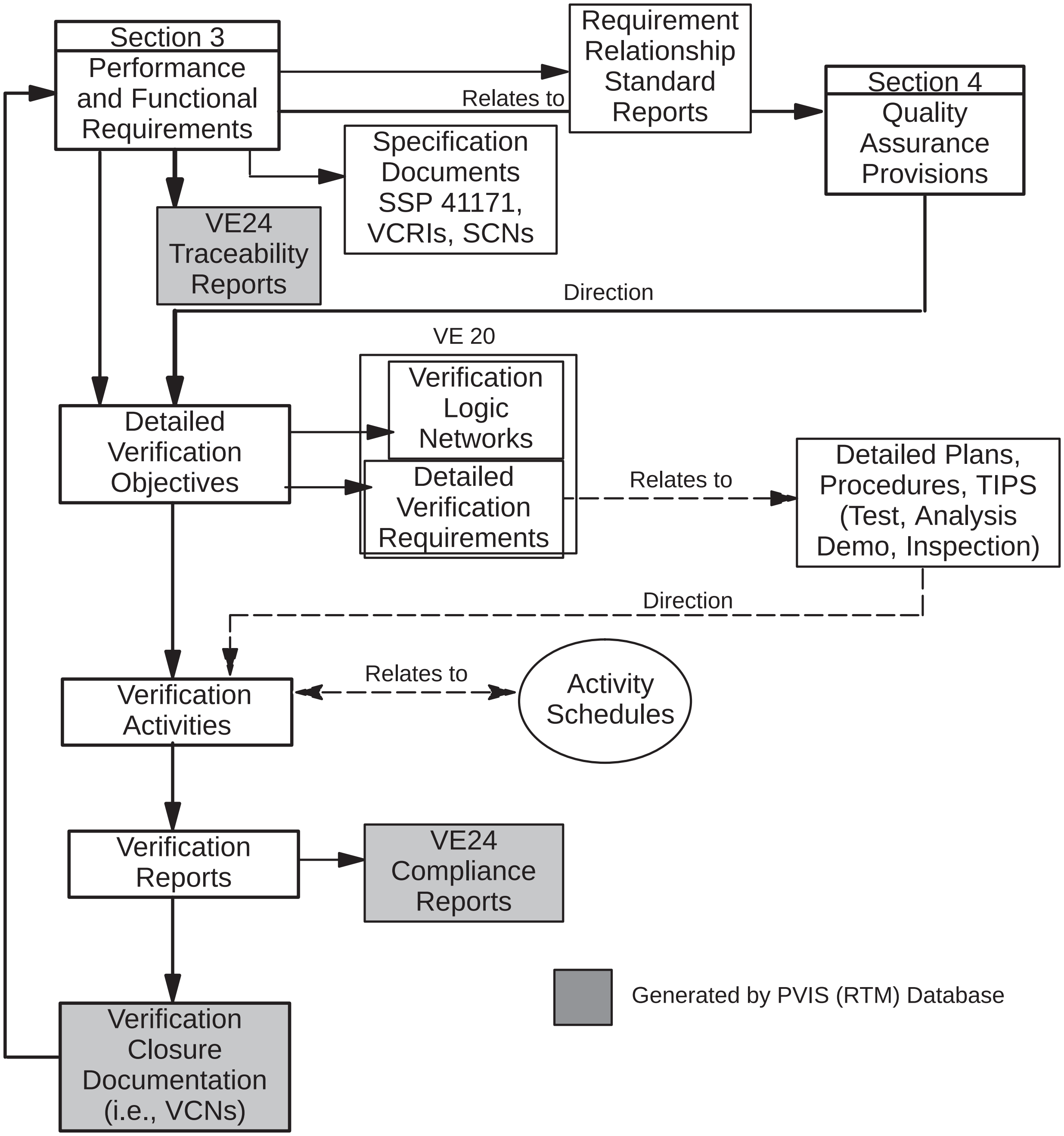


FIGURE 7–3 TRACEABILITY AND COMPLIANCE REPORTING & RELATIONSHIPS TO THE VERIFICATION PROCESS

7.2.3 COMMON CLOSURE DOCUMENTATION

The following products are common to NASA, Prime, and PG institutions:

a. Verification Analysis and Inspection Reports

b. Verification Test and Demonstration Reports

See Section 4.4.3 for a description of these reports.

7.2.4 INTERNATIONAL PARTICIPANTS CLOSURE DOCUMENTS

Verification reports, deliverables and some non–deliverables are also created for the collection, consolidation and publication of verification data from the International Participants when that data is needed for future verification reference, or for delivery to other ISSA teams to support their processes. These verification reports and deliverables include:

a. International Participant Hardware, Software and Data Exchange Lists

b. International Participant Interface Verification Visibility Reports (IVVR)

c. US/International Joint Test Report

d. Acceptance Data Packages

e. Status Reports

f. Metric Reports

International Participants are involved in the development of data for and publication of the International Participant Hardware, Software and Data Exchange Lists, the International Participant Interface Verification Visibility Reports, and any US/International Participant Joint Test Reports. These reports are identified in Table 4–V. A description of these reports is found in paragraph 4.4.3.

7.3 REVERIFICATION

7.3.1 REVERIFICATION GENERAL

When reverification is required, it will encompass the changes in the specification and/or detailed test requirements and sufficient regression testing and reverification to show compatibility with the unchanged requirements. Reverification does not imply all of the original verification performed is repeated.

When test or flight activity is constrained by reverification, the test or flight activity shall not begin until reverification is completed or waived at the highest program level approving the applicable requirements.

Verification traceability is reiterated as part of reverification, as necessary, for any specification requirement changes.

Reverification results will be compared with current hardware and software requirements. Deficiencies, flaws, discrepancies, and/or inadequacies will be identified and corrective action defined.

7.3.2 REVERIFICATION QUALIFICATION

As a result of these evaluations and assessment activities, it may be necessary to re–verify the effort to ensure requirement compliance.

Reverification will be required when any of the following occur:

a. Design or manufacturing process changes have been made which affect function or reliability

b. Inspection, test, mission change, or other data indicate that a more severe environment or operating condition exists than that to which the hardware/software was originally qualified

c. Changes are made in procurement source

d. Changes are made in specification, manufacturing processes or procurement sources for fluids or other materials used in processing or operating the hardware/software

e. Software changes occur that affect requirements or flight software capabilities

7.3.3 REVERIFICATION ACCEPTANCE

Reverification for those activities in the Acceptance Phase will be required when any of the following occur:

a. A previously mated and verified interface has been demated

b. Modification, repair, replacement, or rework occurs after inspection or testing

c. The article or material is subject to drift or degradation during storage or handling

d. Software changes occur that affect requirements or flight software capabilities

8.0 VERIFICATION RESOURCES

The resources available to support ISSA verification include facilities, SE and the PVIS.

8.1 FACILITIES

Existing facilities at NASA centers and at the PGs are used by NASA, the Prime Contractor and the PGs for the performance of verification activities. A new facility, the SVF, is being used by the Prime Contractor to support verification and validation of flight software and data loads. IPs provide their own facilities and SE for verification activities. The items exchanged for verification purposes are documented in the NASA/IP BI&VPS.

8.1.1 FACILITIES CERTIFICATION

Facilities that support the integration and verification program must be certified prior to use. Facilities include the building and specialized structures that support ISSA program activities including those items designed into and an integral part of the structure. All program facilities must be under configuration control and utilities must be certified. Program unique equipment used within a facility will be verified or certified as support equipment, per section 8.2 and not as part of the facility. General purpose test equipment that are utilized as part of and are provided by the facility will be certified by the facility provider.

Requirements which the facility must meet to support the user of the facility will be provided to the facility owner by the user. Requirements will include environmental conditions or operational constraints and identify any necessary utility specifications. The facility owner will certify that the facility will meet the requirements provided by the user. It is the user’s responsibility to ensure that the facility owner provides this certification. A list of facilities used for verification test activities will be included in the user’s MVP. Confirmation of facility certification must be performed prior to start of verification activities and will be included in the verification procedures. This includes certification that the equipment is suitable for the verification purpose and that it bears evidence of valid and current calibration if required. The facility will also bear evidence that it meets ISSA Program and location safety requirements. Certification will be performed per standard commercial practice or approved certification procedures normally used by the facility owner if they meet user requirements (such as those used by Boeing and NASA). For example, facilities controlled by NASA JSC Institution are required by JSC Management Directive 8825.1G to be certified by an Operation Readiness Inspection, if they support major or hazardous testing. Off–site facilities are controlled by JSC MD 8825.2F. It is common to have multiple certifications for a facility to cover commodities (utilities), environments and, hazardous operations.

Hazardous operations are limited to facilities designed for specific hazardous operations. Each facility has design limitations regarding the size and type of hazard the facility was designed to support. Certification of these type of facilities is commonly accomplished by a safety review of the proposed activity and facility capability.

8.1.2 SOFTWARE VERIFICATION FACILITY

8.1.2.1 SVF DESCRIPTION

The SVF, located at the Johnson Space Center, provides an environment and capability for integrating, testing, verifying, and validating Space Station flight software and data loads with multiple Space Station integrated avionics systems, either real or simulated. It has the capability to:

a. Accept copies of integrated flight software releases from the Mission Build Facility (MBF) and manage these releases as well as internal simulation software and SVF software for ground test, verification, validation, and flight operations

b. Verify and certify integrated flight software releases for each stage

c. Validate the integrated flight software releases

d. Conduct configuration management for SVF ground test software releases

e. Support on–orbit anomaly resolution

f. Support verification of capabilities by providing test data

The SVF is built to a set of requirements and verified to show compliance with these requirements. The SVF is developed by incrementally integrating hardware and software components and elements into specific configurations to mimic the staged assembly of the ISSA for the purpose of validating the flight software and data load releases. There are 4 basic processes implemented in the incremental build–up of the SVF.

a. Develop Hardware and Software. Includes the development of hardware and software products by MDC and the integration of those products together with COTS, GFE, and/or CFE products to form the complete SVF system. Integration and test at this level is performed by developers to confirm that all of the individual basic units in the system meet allocation requirements and work together.

b. Verify Requirements. Covers formal verification of SVF HWCI, CSCI and component level requirements in B2 and B5 specifications, and in section 3.7 of the PIDS respectively. It also includes verification of the SVF external interface requirements documented in the applicable ICDs. This verification is performed by the SVF development IPTs in an integrated system configuration.

c. Assess System. Covers end–to–end system test by the SVF AIT to assess system readiness for operational use. Includes measurement of overall performance in the ORD configuration, stress testing, and execution of user scenarios to confirm the overall integrity and usability of the system.

d. Verify System. Verifies overall system functionality reflected in requirements from section 3.2 through 3.6 of the SVF PIDS as the condition for final SVF acceptance by the Prime. The PIDS section 4.0 specifies the test objectives for the individual system functional requirements. These objectives provide the basis from which verification procedures are created.

8.1.2.2 SVF CERTIFICATION

The SVF certification plan and process are implemented as described in the SVF Architectural Notebook.

Initial SVF certification is performed as a part of the “in–process” FCA/PCA for the SVF when it is delivered to the Prime Contractor, and is based on review of documentation, test results and operational results. Just as the SVF requirements are allocated downward to hardware and software items and simulations, the providers of these items are responsible for their verification that ultimately leads to SVF certification. The certification of the SVF builds upon the certification of the SVF components as described in the following paragraphs.

a. Simulations provided to the SVF are certified by their providers. The certification of these simulations is based on their use by the providers during their flight software verification process. This approach establishes the pedigree of the products for use in the SVF. Recertification after problem resolution or controlled change will follow the same process.

b. Similarly, the ESA tools provided to the SVF are certified by ESA. Certification of these tools is based on their use during ESA software and hardware verification activities. Recertification after problem resolution or controlled change will follow the same process. This approach establishes the pedigree of the product for use in the SVF.

c. Multiplexer/Demultiplexer Application Test Environment (MATEs) provided to the SVF are certified by the their manufacturer at delivery as a part of their acceptance process. MATEs are also used by the PGs to develop and verify their flight software. Recertification after problem resolution requiring software/firmware change of controlled change will follow the same process. These activities establish the pedigree of the MATEs for use in the SVF.

Note: In all cases after repair, recertification of COTS hardware will follow standard commercial practices.

d. Within the scope of the incremental FCA/PCA, initial certification will be accomplished based upon the results contained in the verification database. Audit of a selected set of SVF requirements may be performed, as required. The requirements traceability to lower–level requirements will be evaluated and the verification will be examined. The verification documentation related to the closure of the requirements will be examined and evaluated and information generated by the providers of SVF components will be examined. This may results in SVF component modification, flight software re–test, etc., or a combination of these.

Certification of the SVF is accomplished in a building block fashion, and is based on the incremental build of the SVF and the flight software as they progress to their Assembly

Complete configuration. Figure 8–1 depicts this process. Key to the process is the understanding that verification and validation of the flight software for any stage is based on the certification of the SVF configuration and the successful verification and validation of the flight software for the previous stage.

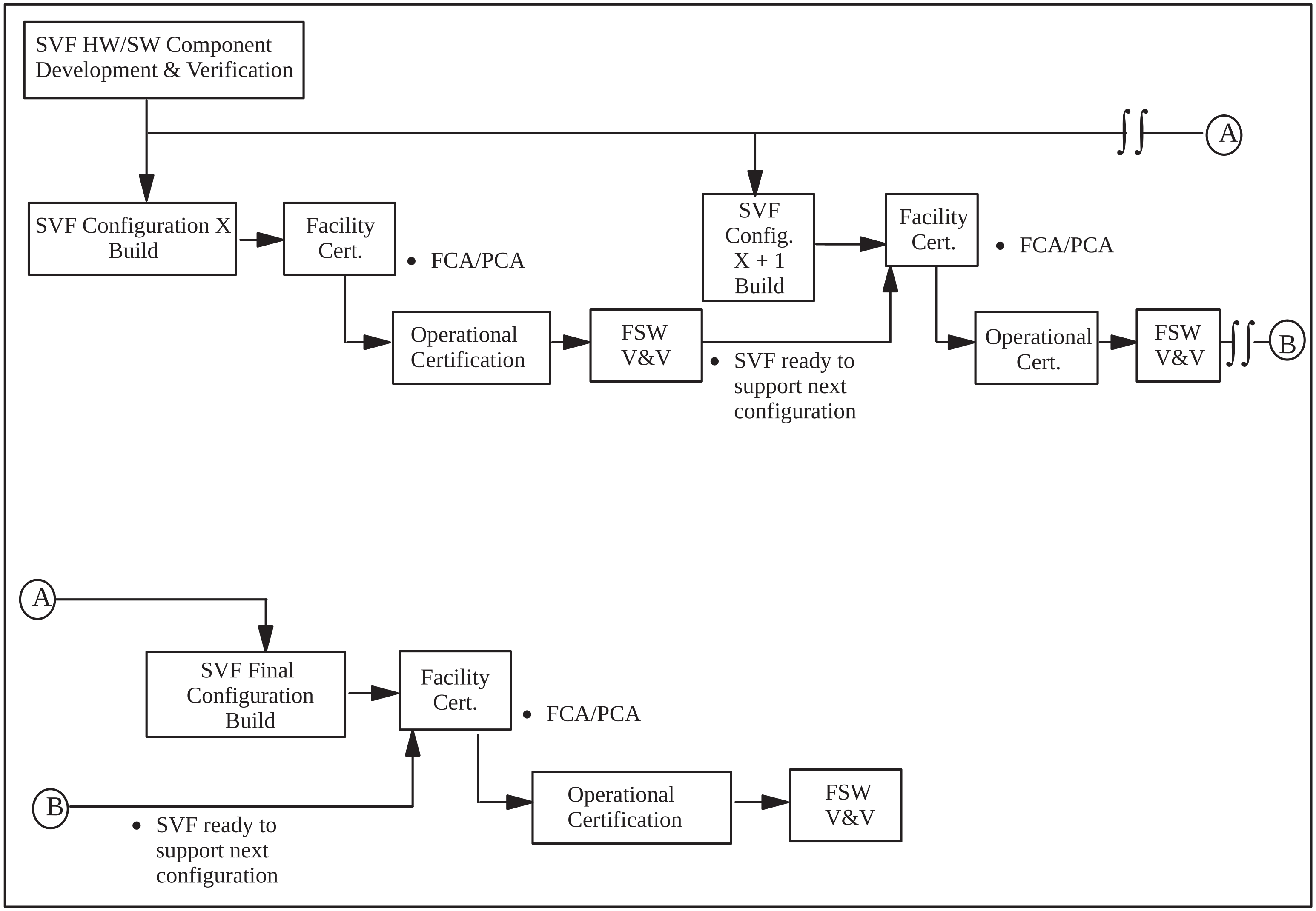


FIGURE 8–1 SVF CERTIFICATION BUILDING BLOCK APPROACH

Note that after initial certification of the first SVF configuration, and succeeding SVF configuration's initial certification will concentrate on that portion of the SVF which has changed from the previous SVF configuration. For all SVF configurations, initial certification will be against early, interim, and final versions of the stage flight software. This is depicted in Figure 8–2.

Flight SW Fidelity				Certification/ Verification Activities
Stage 1 FSW	Stage 2 FSW	Stage 3 FSW	Stage 4 FSW	
Final Release	Interim [1] Release	Interim [1] Release	Early [1] Release	• SVF Initial Cert. • Operational Cert. • Verify Stage 1 SW
Final Release	Final Release	Interim [1] Release	Early [1] Release	• Operational Cert. • Verify Stage 2 SW
Final Release	Final Release	Final Release	Interim [1] Release	• Operational Cert. • Verify Stage 3 SW
Final Release	Final Release	Final Release	Final Release	• Operational Cert. • Verify Stage 4 SW

Note 1: FSW fidelity shown may differ dependant on availability.

FIGURE 8–2 SVF ORD 1 CERTIFICATION AND VERIFICATION ACTIVITIES

For each succeeding SVF configuration, additional incremental SVF certification by use is performed using later, higher pedigree stage flight software and is the responsibility of the Command and Data Handling (C&DH) flight software integration and verification users.

After SVF initial certification but prior to flight software verification test in the SVF, an operational certification will be conducted. Operational certification is primarily a Configuration Management/Quality Assurance/Operations/User activity, where the facility is certified as ready to support a specific test. Verification requests for equipment, software, and data are mapped to build specifications. Builds are monitored as to the pedigree of the source data, software, and equipment to be used for the test. QA/CM and Operations attest to the validity of the configuration. Open facility DRs against HW/SW/Data are reviewed in pre–test briefings and the facility readiness is attested to. Pre–test diagnostics tests are performed as defined in the test preparation documentation to support this process.

8.1.2.3 SVF SYSTEM/SEGMENT SPECIFICATION COMPLIANCE SUPPORT

Data generated during Flight Software (FSW) validation is used to support System and Segment verification activities. The data may support analyses identified in step 2 of the 5–Step

Verification Process (see section 5). The SVF is best suited for providing data which supports verification activities such as integrated sub–system analyses and ISSA System and Segment capability analyses.

8.2 SUPPORT EQUIPMENT

Support Equipment is developed to transport, access, handle, protect, service, or verify a qualification/flight item. The Prime Contractor will develop and manage SE in accordance with the Support Equipment Plan D684–10041–1–5. The various types of SE are: Orbital Support Equipment (OSE); Flight Support Equipment (FSE); Ground Support Equipment (GSE); and Test Support Equipment (TSE). Factory Equipment (FE) including test aids/fixtures and master tooling/jigs are not considered SE. FE is detailed in each subcontractor’s Manufacturing Plan. The design of new SE will be in accordance with the Support Equipment Design Requirements document (SSP 50004), which contains the consolidated requirements for performing the necessary analysis, design, and fabrication for the SE. SSP 50004 will also be used as a guide for the design and development of TSE. FSE and OSE will be designed and verified in accordance with flight hardware criteria and requirements. Support Equipment provided as GFE, or Contractor Furnished Equipment (CFE) will be certified by the provider of the item(s). The specific SE verification of certification methodology to be used for each type of SE is outlined in the following paragraphs. SE used on the ISSA program from other programs (e.g., Freedom) will be handled as described in the SE Plan, D684–10041–1–5.

8.2.1 SUPPORT EQUIPMENT CERTIFICATION

SE certification entails the formal written act whereby a responsible official attests to the satisfactory accomplishment of the specified activities and authorizes the item of SE or SE Test System for program usage. The overall objective of the SE certification process is to ensure readiness of the SE for its intended use. The certification process encompasses: (1) The qualification of the design, fabrication, assembly, and test process, (2) the acceptance of each SE item, (3) the validation of SE software, and (4) the calibration/certification of SE items or SE test setup. At the completion of this process the SE item or SE Test setup is “Certified” for use. All SE shall be certified as being able to meet required objectives prior to interfacing with any Qualification or Flight Hardware or Software. SE items or SE test setup containing “Standards” traceable to NSTS Standards will be calibrated.

All first items of GSE undergo expanded activities that certify the item. Follow–on GSE units require only acceptance testing. SE test setups are defined as a collection of individual items of SE connected together as a system for tests or demonstrations. The integration of a SE test setup interfaces and verifying the compatibility and proper operation of the resulting new system configuration. These SE test setups will be under documented configuration control.

Any changes that occur after the initial certification such as; revised SE requirement, interfacing flight hardware design change etc., will require that the SE be re–certified to the extent that the modification affects the certified design.

Equipment designed and used in support of development testing may be upgraded and certified as SE for use in qualification and acceptance of flight items.

8.2.1.1 SUPPORT EQUIPMENT QUALIFICATION

All first items of SE undergo expanded activities to include analysis, inspection, test and demonstration, that qualify the item as described in D684–10041–1–5. These activities ensure the design, manufacturing and assembly have resulted in SE hardware and software conforming to the design and performance requirements.

8.2.1.2 SUPPORT EQUIPMENT ACCEPTANCE

SE planning will be in accordance with the Configuration Management Plan and will include thorough acceptance activities, to ensure that the SE item meets all the specified requirements (performance, function, operational environment, configuration) and that no manufacturing or workmanship defects exist. The tests themselves will be non–destructive and planned so that refurbishment of the SE item will not be required following successful completion of the acceptance test.

8.2.1.2.1 SUPPORT EQUIPMENT ACCEPTANCE DATA

FCAs and PCAs will be conducted for GSE, FSE, and OSE in accordance with the Configuration Management Plan. An ADP will be required as defined in the Program Configuration Management Plan. A formal ADP will not be required for deliverable TSE. Informal technical data for the deliverable TSE will be provided by the developer.

8.2.1.3 SUPPORT EQUIPMENT SOFTWARE CERTIFICATION

The overall objective of the SE software certification are to ensure that the SE software has been designed, coded, integrated, verified, and validated to support the qualification, acceptance and operational activities of the ISSA. All SE software will be validated as meeting all specified performance and functional requirement prior to interfacing with any qualification or flight items.

8.2.2 ORBITAL SUPPORT EQUIPMENT AND FLIGHT SUPPORT EQUIPMENT

The Verification process for OSE and FSE will comply with all verification requirements for Flight hardware and Software. OSE and FSE shall undergo the required qualification testing and all production units shall be acceptance tested. Qualification and Acceptance requirements for OSE and FSE will be contained in Subcontractor, Supplier, or Vendor Type B Specification documents.

8.2.3 GROUND SUPPORT EQUIPMENT

Ground Support Equipment is defined as that equipment which are contract line item deliverables to support launch processing and post landing operations. The GSE certification process is similar to that used for Flight Hardware Protoflight. GSE certification is based on expected environmental conditions, operational constraints and potential hardware/software failures or conditions which could cause loss of flight systems or injury to personnel. Subcontractor, Supplier, or Vendor SE Requirements Documents, or equivalent, will identify the items functional/performance requirements. Qualification and Acceptance of GSE, will be performed to meet these requirements.

8.2.4 TEST SUPPORT EQUIPMENT

Test Support Equipment is non–deliverable equipment designed for use by the contractors to support; assembly, handling, integration, and qualification and acceptance testing activities, as applicable, at subcontractor and vendor facilities. TSE must be certified prior to interfacing with flight equipment. This certification will ensure the equipment can perform its intended function and meets the desired objectives. Requirements for TSE will be contained in Subcontractor, Supplier, or Vendor internal documents (Hardware Requirements Documents [HRDs] or Envelope Drawings [EDs]), and will identify the items functional/performance and verification (qualification and acceptance) requirements.

8.2.5 COMMERCIAL OFF–THE–SHELF

Commercial off–the–Shelf hardware and/or software will be analyzed in detail, against the conditions for the planned use of that item. COTS software products are characterized as "certified by use" and hardware products are certified using standard commercial practices, (e.g.; Cal./Cert. Lab). The integration of COTS products with other products, including other COTS products, do require certification testing such as the performance of diagnostics to certify readiness to support testing. This may be accomplished individually or as a composite set of hardware and software using standard commercial practices.

8.3 PROGRAM VERIFICATION INFORMATION SYSTEM

8.3.1 OVERVIEW

Verification documentation provides the relationships between hardware and software specification requirements, verification requirements, detailed verification objectives, verification activities, and closure documentation, as depicted in the Verification Traceability Process Mechanization, Figure 8–3. When viewed in the perspective of having hundreds of specification documents and thousands of requirements, this relationship requires the use of on–line relational database management systems, which provide flexible reporting to support a number of program milestone reviews. The importance of a centralized and controlled system is essential to reduce the effort involved in evaluating downstream changes. The PVIS database provides this capability.

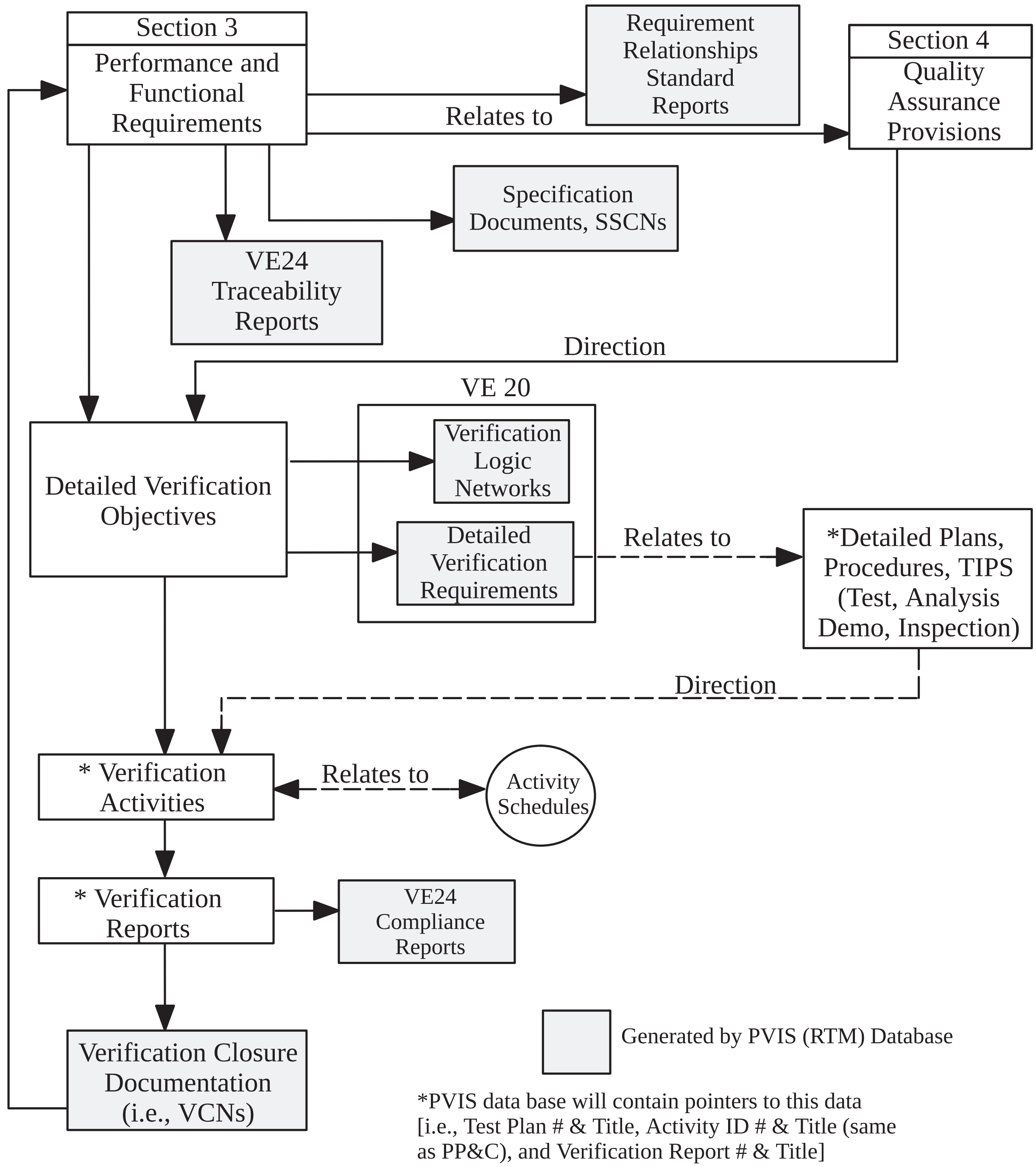


FIGURE 8–3 VERIFICATION TRACEABILITY PROCESS MECHANIZATION

8.3.2 SYSTEM FUNCTIONS

PVIS system functions include providing requirement and verification traceability data in support of the 5 step verification process, described in sections 5, 6, & 7, Assembly, Checkout, Operations, Maintenance, and Configuration requirement traceability, described in section 9, automates generation of specification documents and contractual DRs, on–line access to current requirements status, visibility for impact assessment, and data transfer between sites and organizations. Each of these functions is defined in the PVIS Process Document (D684–10021–1), and the PVIS Software Requirements Specification, (SW684–10022–1).

PVIS set–up and overall management is the responsibility of the Prime Contractor. The PVIS database will be developed in concert with the supporting organizations involved in the ISSA Program. The connectivity, privileges, attributes, data transfer functions, and database configuration management are defined in the PVIS Process Document and PVIS Software Requirements Specification.

8.3.2.1 TRACEABILITY PROCESSES

The RTM data structure serves as the ISSA Program standard for traceability management. PVIS provides the tool for the traceability of requirements allocation through verification implementation to the closure reports documentation as shown in Figure 8–3. PVIS provides the automated capability needed to manage and control the verification program to ensure that all program requirements are satisfied.

By tracking activity completions in a relational database that also handles requirements traceability data, PVIS is capable of generating the required verification closure documentation.

8.3.2.2 REPORTS

PVIS provides the capability to generate user defined, standard, contractual, and interface verification visibility reports for statusing requirement closure.

8.3.2.2.1 USER DEFINED REPORTING CAPABILITY

PVIS provides a real–time user defined reporting capability to support the program processes and milestone reviews. For reports too complex for the user to define, or for reports that recur frequently, standard reports will be developed and added to the PVIS report menu.

8.3.2.2.2 STANDARD REPORTS

PVIS will contain a standard list of reports that are available from the PVIS report menu. These reports will be developed to standardize the data in a format common to all organizations. Standard reports will also be developed for formal reviews and data gathering purposes. The content of the standard reports is described in the PVIS Software Requirements Specification.

8.3.2.2.3 CONTRACTUAL REPORTS

PVIS will generate Data Requirements, VE20 Integration, and Verification Requirements for USOS and ISSA System and VE24 Specification Traceability and Compliance Reports. The contents of these reports are described in the PVIS Software Requirements Specification.

8.3.2.2.4 INTERFACE VERIFICATION VISIBILITY REPORTS

PVIS will generate Interface Verification Visibility Reports as described in section 5.

8.3.2.3 DATA TRANSFER PROCESSES

The data transfer process will ensure consistency among organizations and provide all database systems with the latest revised data. The transfer of data will be accomplished, as defined in the PVIS Process Document and PVIS Software Requirements Specification.

8.3.2.3.1 PRODUCT GROUPS AND LMSC

Data transfer between the Prime Contractor and Product Groups' or LMSC databases will be coordinated and established to allow the transfer and delivery of formal data. Updates to the PVIS database will occur after updates are made to the Product Groups' or LMSC database systems. Only baselined data will be transferred to PVIS. PVIS controlled data, necessary for Product Group and LMSC inputs and impact reports, will be provided electronically to the applicable Product Group and LMSC databases. Electronic access to the Product Group's and LMSC databases (excluding PG–2 EPS Database) provides the Prime Contractor visibility into the Product Groups' and LMSC verification process without requiring hard copies of status reports.

8.3.2.3.1.1 PRODUCT GROUP 1

McDonnell Douglas Aerospace Product Group 1 (PG–1) will interface with the PVIS database by remote access to enter PG–1 RTM data and will be able to generate reports from the PVIS database. PG–1 data is all contained within the PVIS database. PG–1, utilizing PVIS, will collect and track requirements, which are allocated to a deliverable item, assembly, or component.

8.3.2.3.1.2 PRODUCT GROUP 2

Rocketdyne Product Group 2 (PG–2) will interface with the PVIS database by remote access and will be able to generate reports, locally at Rocketdyne, from the PVIS database. PG–2 will utilize RTM as the traceability tool for required ISSA specifications. PVIS support and access to the database will be provided to PG–2 by the Prime Contractor. PVIS will collect and track requirement traceability information for design and acceptance requirements below the PIDSs.

The EPS database, will collect and track verification information on the current status of design and acceptance requirements, which are allocated to a deliverable item. PG–2 will be responsible for transferring data from the EPS database to RTM and from RTM to various applications at Rocketdyne with full support from the Prime.

8.3.2.3.1.3 PRODUCT GROUP 3

Boeing Product Group 3 (PG –3) will interface with the PVIS database through the RTM data partitioning function for transferring RTM data and will be able to generate reports from the

PVIS database. PG–3, utilizing RTM, will collect and track requirement and verification information on the current status of design and acceptance requirements, which are allocated to a deliverable item, assembly, or component. The prime contractor will have remote access for performing queries of PG–3 RTM data.

8.3.2.3.1.4 LMSC

Lockheed will interface with the PVIS database by remote access. Khrunichev will provide FGB verification compliance data to Lockheed in paper copy format. Lockheed will enter PVIS data, and will be able to generate reports from the database.

8.3.2.3.2 NASA

NASA will interface with the PVIS database by remote access to enter traceability and compliance data and will be able to generate reports from the PVIS database. KSC has established the Payload Data Management System (PDMS). The PDMS is used to track and status the Operations & Maintenance Instruction (OMIs) for the Assembly, Checkout Operations, Maintenance and Configuration (ACOMC) requirements that are contained in PVIS. PVIS will contain the OMI numbers to be able to obtain KSC processing data from PDMS. PVIS will contain the ODF name to be able to obtain MOD data from the MOD database.

8.3.2.3.3 INTERNATIONAL PARTICIPANTS

The International Participants will interface with the PVIS database by remote access, if desired, and will be able to generate reports from the PVIS database. The International Participants will be able to enter requirement and verification data in the PVIS database. The International Participant’s usage of the PVIS database is defined in the BI&VPs.

8.3.2.3.4 PRIME DATABASE INTEGRATION OF DATA

The PVIS database will contain pointers to various Prime Contractor database systems allowing the identification of specific program data. Key data fields will be established in PVIS to point to the various database systems to obtain additional information. Information will include hardware configuration, scheduling activities, performance, and characteristics data. These pointers provide the capability to obtain the necessary information for detailed monitoring of schedule and cost impacts. Pointers will be provided only to baselined program data.

8.3.2.3.4.1 PROGRAM PLANNING & CONTROL

Program Planning and Control (PP&C) will track scheduled verification activities and will be able to forecast potential schedule impacts. PVIS will identify the PP&C identification number for each applicable verification activity.

8.3.2.3.4.2 VEHICLE MASTER DATA BASE

Vehicle Master Data Base will provide part numbers, weight, mass, reliability, maintainability, FMEA/CIL, Limited Life, connectivity, performance, and characteristics data. This information will provide current status on contract items that are identified as non–conforming to the original specification, contract items that are identified as acted upon by the reliability and maintainability organization, or contract requirements that are identified on the hazard reports of the safety organization. PVIS will identify the VMDB item part number and name.

8.3.2.3.4.3 OPERATIONS

The operations database uses RDD–100 for functional decomposition data and operational scenarios data. PVIS will contain pointers to the operations database to obtain this data.

9.0 OTHER INTEGRATION AND VERIFICATION ACTIVITIES

This section discusses those Integration and Verification (Non-Specification Compliance) activities not covered in sections 5, 6 and 7 of this document. Essentially, it addresses those activities that support Launch processing at KSC, on-orbit assembly and checkout and Payload Verification. Figure 9–1 depicts the overall Stage Buildup flow that is generally followed until Station Assembly Complete.

The intent of this section is to describe in detail the Stage Buildup process, identify the participants who are responsible for the various parts of the process and identify the documentation that plans and implements the process. This detail process is depicted in Figure NO TAG.

This section does not levy any new requirements or create new tasks for the responsible organizations. Rather, the intent is to show how it all fits together to assure that no requirements or tasks were inadvertently omitted.

9.1 LAUNCH PACKAGE ACTIVITIES

9.1.1 LAUNCH SITE PROCESSING

Physical launch package Integration and Prelaunch/Post landing Operations are described in the Concept of Operation and Utilization Volume 1, Principles Document D684–10001–01, section 5 and Concept of Operation and Utilization Volume 2, Profiles and Scenarios D684–10001–02, section 4, Function 5. Applicable launch site activities will be performed as described in The Prelaunch/Postlanding Operations Integration Plan, Volume 1 (DR OP03). Efforts at the launch site will ensure the hardware and software meet Orbiter interface requirements, safety and Program defined requirements, and will prepare station hardware for flight. Interface requirements contained in ICDs and joint verification requirements contained in Joint Verification plans and agreements are part of the specification compliance verification program addressed in sections 5, 6 and 7 of this document. Assembly and checkout activities conducted during launch package processing confirm the fit, form, and function of the flight hardware and software items.

Launch site processing activities are performed at KSC following end item acceptance by the Prime prior to launch. Each element will have a unique set of requirements for Launch site processing, which may consist of any or all of the following activities:

a. Hardware delivery and receiving inspection

b. Preintegration, which involves any preparation for functionality testing

c. Functionality testing to the Program defined requirements

d. Launch Package Integration

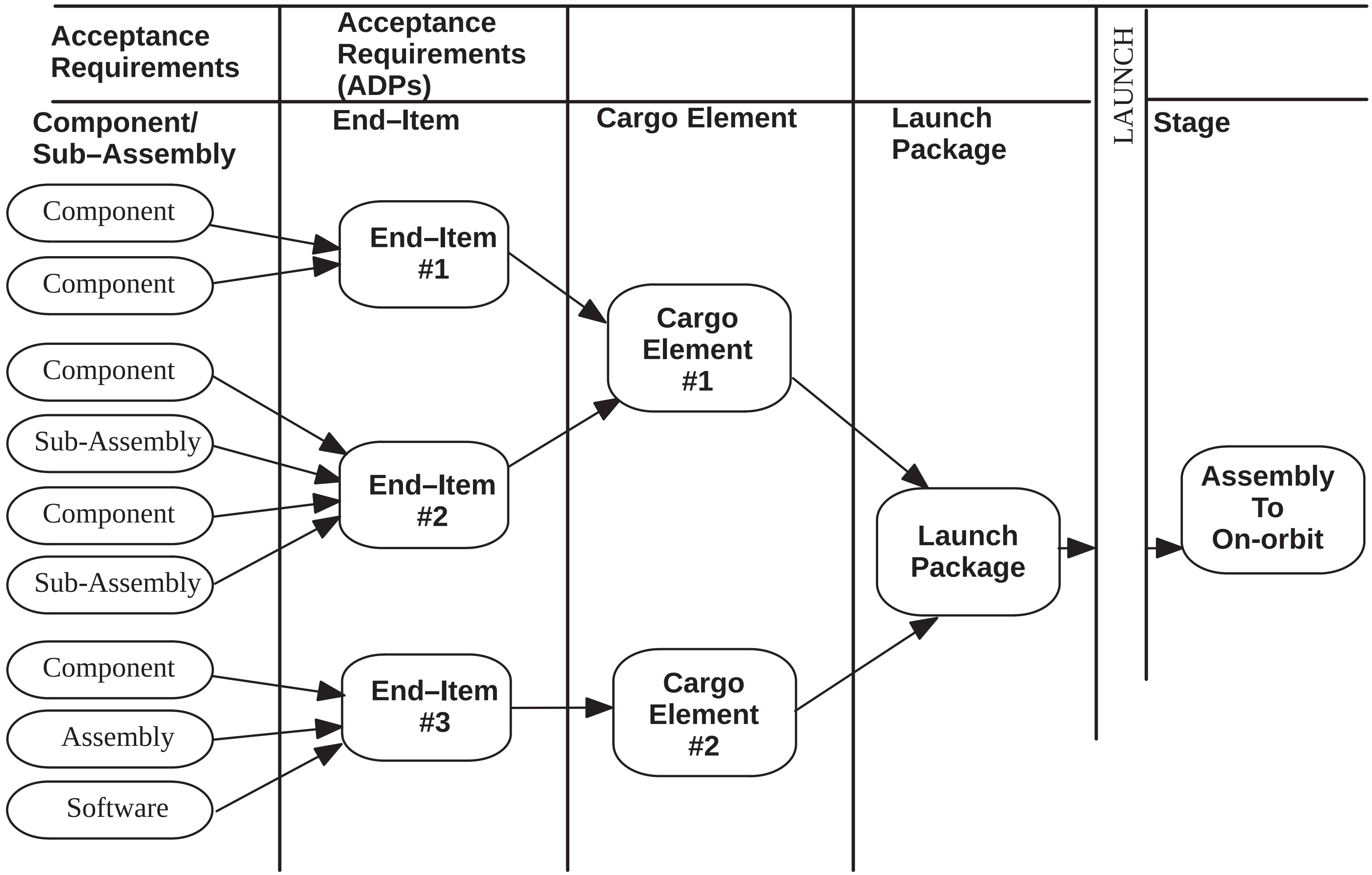


FIGURE 9–1 STAGE BUILDUP FLOW

e. Hazardous Servicing

f. NSTS Integration, Operations and Tests to integrate the payload into the orbiter and the interfaces involved

g. Countdown Operations including preflight checks

Activities A thru E are performed by the Prime with support from KSC/NASA. Activities F and G are performed by NASA/KSC with support from the Prime.

Launch site processing ensures that all Launch elements are properly prepared, configured and ready for launch. A graphical representation of the generic KSC Flow is presented in Figure NO TAG, Launch Site Flow. All ISSA launch site processing will be accomplished in accordance with approved program test and verification requirements as defined in the ISSA program controlled database (PVIS) (ACOMC subsection) and the NSTS Operations and Maintenance Requirements and Specifications (OMRS). The launch package processing is completed with launch.

The requirements and associated planning for these activities will be documented in DR 0P03, Prelaunch/Post Landing Operations Plan and Requirements.

9.1.1.1 RECEIVING AND INSPECTION

Launch site activities will begin with carrier unloading. Space Station hardware will be transported to the Space Station Processing Facility (SSPF) for unpacking and receiving inspection activities.

Receiving and inspection personnel will inspect and document the quantity and condition of hardware as it arrives at the launch site. The ADP accompanying the element will be checked for completeness. A receiving inspection will be performed to ensure packaging integrity, retrieval of transportation instrumentation data, proper labeling, and confirmation of installed integrity seals. Any anomalies will be documented through quality control, including quantity and condition of flight hardware by the Prime.

Ship short/open–work items will be reviewed to determine if existing capabilities can perform this work or if additional capabilities are required. Capabilities for completion of approved shipshort/open work will be provided. The Prime is responsible for successfully closing shipshort and open-work items.

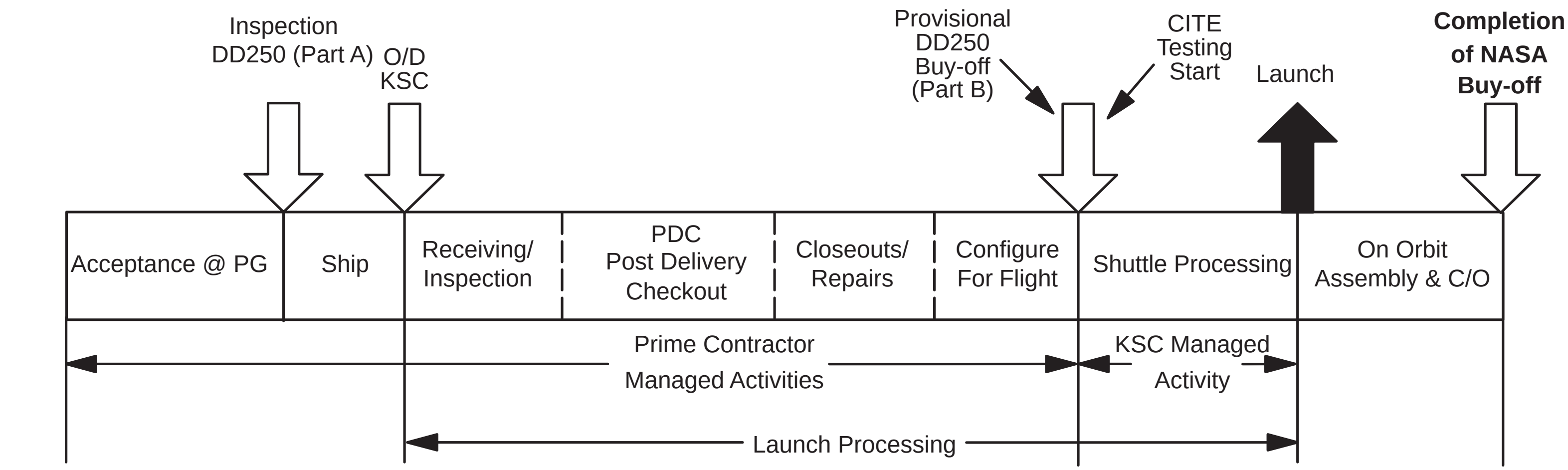
9.1.1.2 PREINTEGRATION

Preintegration activities will include preparation of the end items for functionality testing and will include servicing, fluid line leak checks, bus isolation tests, and assembly or modifications. Post Delivery Checkout (PDCO) will be performed to ensure that no internal or non–inspectable shipping damage has occurred, and that the end items are functional and ready to proceed into planned integration activities.

9.1.1.3 FUNCTIONALITY TESTING

Procedures for any integrated testing will be developed and managed based on requirements provided via the PVIS. Functional testing of KSC–mated end item interfaces will be performed.

No Scale Model (PG1 & PG3):



No Scale Model (PG2):

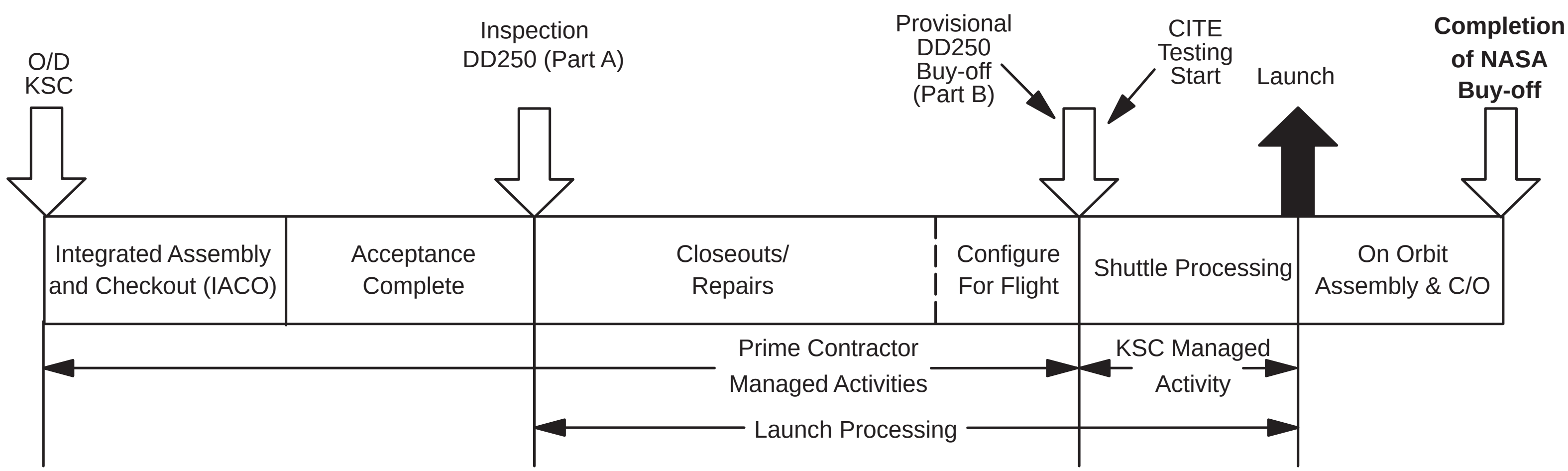


FIGURE 9–2 LAUNCH SITE FLOW (US ELEMENTS ONLY)

The functionality test will be supported utilizing Program approved tooling, flight hardware, simulators/simulations, GSE, as well as BIT/BITE, onboard checkout, and flight instrumentation capabilities.

Tests on flight hardware will not be accomplished for the first time at the launch site. The functionality testing will be conducted within the restrictions of the launch site processing facility ambient environmental conditions. The tests will be limited to the nominal range of the operational parameters, and will be some subset of the factory acceptance test requirements. Integrated tests and checkout performed at the factory will not be repeated unless required to satisfy integrated checkout requirements in a higher fidelity environment.

No off–nominal stress testing or verification of performance capabilities will be performed.

9.1.1.4 LAUNCH PACKAGE PHYSICAL INTEGRATION

Launch Package physical integration involves assembly of end items into a launch package by the Prime. Testing the launch package against a simulator of the NSTS may be conducted by NASA/KSC with the support of the Prime. These NSTS checks are performed using Cargo Interface Test Equipment (CITE) and involve the physical and functional interfaces between launch package items and the NSTS. This activity is performed to ensure proper operation of the launch package with the orbiter systems prior to payload bay installation.

9.1.1.5 NSTS INTEGRATION, OPERATIONS AND TESTING

Integrated Orbiter checkout are the functional pad tests that check out any launch package–to–Orbiter interfaces after the launch package is installed in the payload bay. Mechanical, data, and electrical interfaces will be checked as required. Procedures will be developed from Operations and Maintenance, Requirements and Specification Database (OMRSD) and ICD requirements to accomplish this activity and will be integrated into the NSTS procedures or Joint ISSA/NSTS verification procedures as agreed to in Joint plans or agreements (see sections 5, 6 and 7 of this document for more detail).

9.1.1.6 COUNTDOWN OPERATIONS

During Launch countdown operations, required prelaunch checks are performed on the launch package via launch system monitoring, as required. Procedures will be developed by the Processing Team (PT) and integrated into the countdown procedures. All waivers/exceptions will be addressed by the Program and the Launch Commit Criteria (LCC) change process.

9.2 ON–ORBIT ASSEMBLY AND CHECKOUT

9.2.1 ASSEMBLY AND CHECKOUT VALIDATION ACTIVITIES

Planned on–orbit pre–assembly, assembly, and post–assembly checkout activities will be developed for each launch package and stage and validated prior to launch as described in the Operation Analysis and Integration Plan (OAIP) and COU Volume 3.

One purpose of these validation activities is to demonstrate viability of the human engineering design, including internal and external crew interfaces and tasks, and worksite integration.

Pre-assembly activities include those post-launch activities which prepare the launch package item for assembly. Assembly activities include all Intravehicular Activity (IVA), Extravehicular Activity (EVA), robotic, and combined EVA/robotic activities required to integrate the launch package with the on-orbit stage. Post-assembly checkout activities are those required to activate and operate subsystems.

Assembly and checkout validation activities will ensure, prior to launch, that the ISSA can be assembled and activated safely and efficiently. Validation activities required to satisfy IVA, EVA and Robotic specification requirements are considered verified as defined by the IT&V Five-step process described in section 5, 6 and 7 of this document.

Data for procedure development is available within each Product Group and International Participant for their end items. The PVIS database contains an ACOMC section, which can accept this data for procedure development.

Assembly and checkout validation will be completed prior to final CoFR sign–off for each launch package.

9.2.2 ON–ORBIT ASSEMBLY AND CHECKOUT PLANNING

On–orbit Assembly and Checkout (OACO) provides data for the validation of models, simulations, and analyses. Planning activities will identify the systems and the required data needed to confirm successful assembly and checkout. Participants will identify special tests, activities, and data required to validate analytical models and simulations.

The Prime Contractor will determine requirements for on–orbit pre-assembly, assembly, and post-assembly, checkout verification process operations. The results will be included in ACOMC documentation, under the cognizance of the appropriate NASA organizations.

9.2.2.1 ON–ORBIT ASSEMBLY AND CHECKOUT IMPLEMENTATION

NASA MOD, with support from the Prime and launch package IPTs, will develop planning, assembly, and operational products (integrated Operations Scenarios, procedures, mission rules, etc.) for on–orbit assembly, systems activation, and checkout activities. NASA MOD will be responsible for detailed mission planning, flight controller, and crew training and mission execution of all on–orbit checkout activities.

9.2.2.1.1 ON–ORBIT TEST AND ACTIVITIES REQUIREMENTS DEVELOPMENT

The Prime Contractor may develop requirements for special on–orbit tests, activities or data needed for validation of verification methods. These requirements will be contained in the Assembly, Checkout, Operations, Maintenance and Configuration Requirements section within PVIS, as described in section 9.3. NASA MOD will have access to the ACOMC requirements that reside in PVIS.

9.2.2.1.2 ON–ORBIT ASSEMBLY AND CHECKOUT PROCEDURES

NASA MOD, with the support of the Prime and Launch Package IPTs, will develop the on–orbit ODF procedures required to implement the special activities or tests requirements contained in PVIS. These procedures will be validated per section 9.5.

9.2.2.1.3 ON–ORBIT REQUIREMENT CLOSEOUT

Data received from special on–orbit tests and activities performed will be stored in the Orbiter Data Reduction Complex (ODRC) at JSC. The Prime Contractor and the Launch Package teams are responsible for data analysis and ACOMC requirement closure documentation associated with the on–orbit requirements in PVIS.

9.3 ASSEMBLY, CHECKOUT, OPERATIONS, MAINTENANCE, AND CONFIGURATION REQUIREMENT PROCESS (ACOMC)

ACOMC requirements are developed for activities that will be implemented at Kennedy Space Center (KSC) or On-Orbit. The ACOMC requirements will be contained in the PVIS database. KSC organizations are responsible for developing the procedures for the ACOMC requirements that require implementation at KSC.

9.3.1 GENERAL ACOMC REQUIREMENTS PROCESS

ACOMC requirements are not used to satisfy verification activities for compliance to a specification. ACOMC requirements implemented by KSC are operational in nature and are developed to checkout the product functionality prior to launch. ACOMC requirements are largely derived from the acceptance requirements DVOs, operations analyses, and logistics data.

9.3.2 ACOMC GROUND RULES

The ground rules required for developing ACOMC requirements are found in the PVIS process document, D684-10021-1.

9.3.3 ACOMC PROCESS PROCEDURES

The ACOMC process procedures are found in the PVIS process document, D684-10021-1.

9.3.4 ACOMC REQUIREMENTS TRACEABILITY

The ACOMC requirement traceability process for the assembly and checkout and Launch Package Processing requirements is shown in Figure 9–3.

9.3.5 ACOMC REQUIREMENTS AND DATA DOCUMENTATION

ACOMC requirements are established and maintained in the PVIS database with any required ACOMC requirement traceability data. The scope of these ACOMC requirements, contained in PVIS, are documented in the PVIS Process and Software Specification Documents.

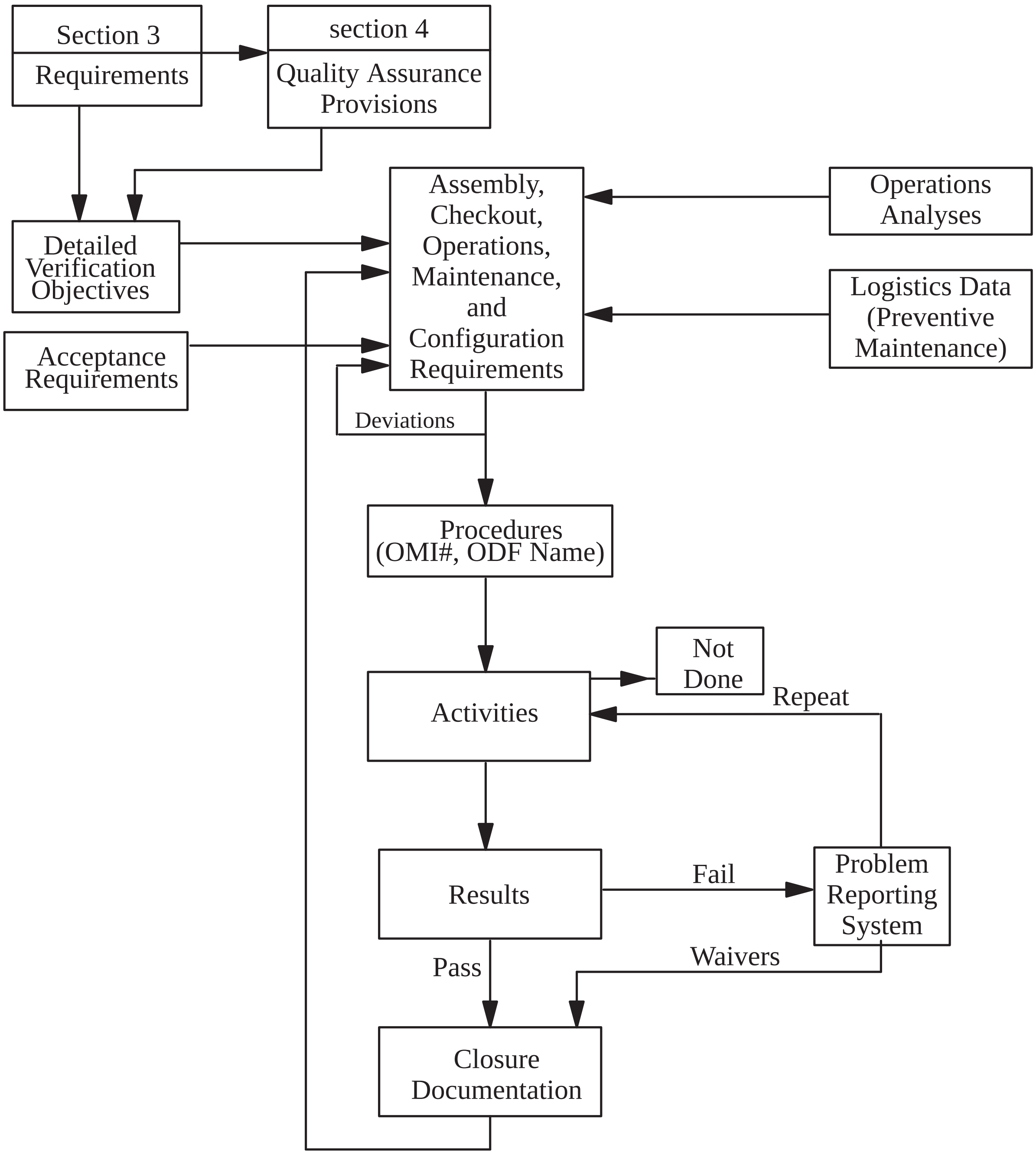


FIGURE 9–3 ACOMC REQUIREMENT TRACEABILITY PROCESS

The OMI number or ODF name associated with each ACOMC requirement will also be identified in the PVIS database.

A relationship will be established between each ACOMC requirement and the applicable procedures. Additional relationships will be established in the PVIS database to identify the applicable ACOMC activities associated with OMIs and ODFs. The results of these activities will also be identified in the PVIS database. Applicable activities that are identified in the PVIS database, but not completed or performed will be statused until either a waiver or deviation is issued or the activity is completed or performed. Any waivers, that result will be identified in the PVIS database. PVIS will provide the capability to generate the ACOMC requirements documents and closure reports.

9.3.6 CLOSURE DOCUMENTATION

Closure documentation will be generated from the PVIS database as a formal means of documenting the compliance with the ACOMC requirements. The closure documentation form will identify the applicable ACOMC requirements satisfied, and is signed by all applicable organizations.

9.4 ISSA PAYLOADS

This paragraph is included here for information. The PMI&VP does not apply to ISSA payloads; these payloads are covered by the Payload Verification Program Plan, SSP 30473.

9.4.1 PAYLOAD VERIFICATION PROCESS

The payload verification process establishes the compliance of as–built payload hardware and software with all applicable design to specifications imposed by the Payload Accommodations Handbook and integration agreements, and safety requirements. The process encompasses all phases of payload integration and operations, i.e., ground processing, transportation to and from orbit, and on–orbit operations.

Requirements which drive payload design or operation are subject to the verification processes established in the Payload Verification Program Plan. The Science and Utilization IPT is responsible for verification of the requirements which drive the design of the payload.

Interfaces between the payloads and the station are controlled using ICDs. The International Standard Payload Rack (ISPR) ICD controls the rack to station interface. Software Command and Data Handling interfaces are defined in the station Payload Executive Software (PES) interface documentation. All payload–to–station interface requirements imposed upon the user are explicitly defined in the Payload Accommodation Handbook and are agreed to in the payload developer Payload Integration Agreement.

9.4.2 PAYLOAD VERIFICATION RESPONSIBILITY

The process provides for delegating the responsibility for planning and implementing verification appropriate to each level of payload integration to the organization responsible for that integration.

Individual payload developers will plan and implement verification of the compliance of their experiment hardware and software with performance specifications and design–to specifications imposed by the Payload Accommodations Handbook and by ISSA interface agreements, and all applicable safety requirements.

Payload rack integrators will plan and implement verification to show that the integrated payload racks comply with the requirements and constraints for integrated payload to rack interfaces, that the integrated rack complies with the ISPR ICD, and that any safety hazards created by the integration of payloads into the rack are eliminated or controlled.

The ISSA element payload integrators will plan and implement the process for verifying that the complement of payloads integrated into the element is compatible with the element to payload interface accommodations and constraints, and that any safety hazards resulting from the integration of the payload complement with the element or resulting from interaction of payloads with each other are eliminated or controlled.

The planning and implementation of the verification process for the total station payload complement is the responsibility of Manned Base Payload Analytical Integration (PAI). This results in the verification of the total station payload complement and the launch and re–entry payload complements interface compatibility and safety compliance. This provides the basis for certification of payload interface compatibility and safety.

The detailed requirements for the payload verification program are contained in SSP 30473, Payload Verification Program Plan (PVPP), prepared by the Science and Utilization (S&U) team.

9.4.3 PAYLOAD ON–ORBIT OPERATIONS PROCEDURES

Preliminary payload procedures for on–orbit science activities are validated during payload design verification. Procedures are shown to be correctly formatted, to not cause hazards and to meet payload objectives.

Final Payload Operations Data File (PODF) procedures are validated during payload integration activities to verify the payload is compatible with the payload increment, is not hazardous, and does not interfere with station operations. Crew training activities provide inputs to the PODF procedure development and validation. Changes to PODF procedures resulting from training validation or crew recommendations based upon prior use are incorporated before final procedure certification and reviewed. When the review determines changes are significant or are the result of payload design changes, the procedure is revalidated by the appropriate payload customer.

9.4.4 PAYLOAD GROUND PROCESSING OPERATIONS PROCEDURES

Preliminary payload ground processing operations procedures are validated during prelaunch activities, and final payload ground processing operations procedures are reviewed before final certification. Changes to procedures to simplify use, resulting from training, ground processing operating requirements, or prior use are reviewed. When changes are significant or are the result of payload or GSE design changes, a procedure is revalidated.

9.5 SYSTEM OPERATIONAL PROCEDURES VALIDATION

Procedures used to control increment operations for systems and flight support equipment are developed iteratively. The integration and verification program provides input and support to the development of these procedures. During integration and verification activities, procedures in various stages of development are utilized and manipulated to support procedures validation by

NASA/MOD. The activation and checkout Operational Sequence Diagrams (OSDs) will be demonstrated on the end items. Procedure characteristics and related inputs are provided to procedure reviews by JSC to support development and validation by the operations community.

Procedures are validated both as preliminary procedures and as final procedures. Reviews are held to support validation. Results of preliminary procedure validation are inputs to final procedure development.

9.5.1 SYSTEM INCREMENT ON–ORBIT OPERATIONS PROCEDURES

Preliminary System Operations Procedures which are ultimately used for on–orbit operations, including on–orbit maintenance, are updated as needed if new data is acquired during qualification, acceptance activities and crew training activities which involve the associated hardware and software. Flight equivalent hardware is preferred during activities that validate these procedures. Procedure simulation, comparison or engineering analysis may be used to support validation, as well. Traceability of each validated test, operations and maintenance requirements specification procedure is provided to the operational requirement governing its use. Traceability is documented for test and preventive maintenance procedures.

9.5.2 SYSTEM INCREMENT PRELAUNCH AND POST LANDING PROCEDURES

Preliminary prelaunch and post landing system operations procedures are validated in the same manner as system increment on–orbit operation procedures. Simulators, simulations or non–flight hardware is used to validate procedures associated with ground transportation and handling of systems and hardware.

Final Operations Maintenance Instructions (OMI) procedures are validated through review by the Combined Processing Team (CPT) to ensure requirements and constraints of requirements, specifications launch site facilities, and GSE capabilities are met. Review results may recommend revalidation when validated final procedure changes are significant or when changes are made to GSE designs.

9.5.3 SYSTEM INCREMENT FLIGHT SUPPORT OPERATIONS PROCEDURES

Increment flight support operations procedures are validated in the same manner as System Operations Data File (SODF) procedures except that Space Shuttle Program participates in the development and validation reviews.

APPENDIX A ABBREVIATIONS AND ACRONYMS

A&CO	Assembly and Checkout
A&I	Assembly and Installation
A&T	Assembly and Test
ACOMC	Assembly, Checkout, Operations, Maintenance, and Configuration
ACRV	Assured Crew Return Vehicle
ADD	Architecture Description Document
ADP	Acceptance Data Package
AD/RT	Architectural Design/Resource Team
AF	Assembly Flight
AIRD	Assembly Integration Requirements Document
AIT	Analysis and Integration Team
AL	Airlock
APM	Attached Pressurized Module
AR	Acceptance Review
ARMS	Automated Requirements Management System
ASI	Agenzia Spaziale Italiana
ATV	Automated Transfer Vehicle
BI&VP	Bilateral Integration and Verification Plan
BIT	Built–In Test
BITE	Built–In Test Equipment
C/O	Checkout
CCRF	Canister Cleaning and Rotating Facility
CDD	Capability Description Document
CDR	Critical Design Review
CE	Cargo Element
CFE	Contractor Furnished Equipment
CFEL	Contractor Furnished Equipment List
CG	Center of Gravity
CI	Configuration Item
CID	Critical Item Development Specification
CIL	Critical Items List
CITE	Cargo Integration Test Equipment
CLIN	Contract Line Item Number

CM	Configuration Management
COF	Columbus Orbiting Facility
CoFR	Certification of Flight Readiness
COQ	Certificate of Qualification
COTR	Contracting Office Technical Representative
COTS	Commercial–off–the Shelf
COU	Concept of Operations and Utilization
CPT	Combined Processing Team
CR	Change Request
CSA	Canadian Space Agency
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CTT	Combined Test Team
C&DH	Command and Data Handling
C&T	Communication and Tracking
DAR	Design Acceptance Review
DC	Docking Compartment
DCR	Design Certification Review
DID	Data Item Description
DOD	Department of Defense
DR	Data Requirement
DRT	Diagnostic Rhyme Test
DSM	Docking and Stowage Module
DTA	Dedicated Test Article
DVO	Detailed Verification Objective
DVR	Detailed Verification Requirement
ECLSS	Environmental Control and Life Support System
ED	Envelope Drawing
EDM	Electrical Discharge Machining or Engineering Development Model
EEE	Electrical, Electronic, and Electromechanical
EESII	Element–Element System Interface Integration
EI	End Item
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMP	Engineering Master Plan

EP	Electrical Power
EPS	Electrical Power System
EPSD	Electrical Power System Database
ESA	European Space Agency
ETA	Engineering Test Article
EVA	Extravehicular Activity
EVR	Extravehicular Robotics
FCA	Functional Configuration Audit
FDD	Functional Decomposition Document
FE	Factory Equipment
FEU	Flight Equivalent Unit
FGB	Functional Energy Block (Russian Term)
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FQT	Formal Qualification Testing
FRR	Flight Readiness Review
FSE	Flight Support Equipment
FSW	Flight Software
GFE	Government Furnished Equipment
GFP	Government Furnished Property
GFM	Government Furnished Material
GN&CP	Guidance, Navigation and Control and Propulsion
GP	Ground Processing
GSE	Ground Support Equipment
GSS	Ground Support System
HRD	Hardware Requirement Document
HSI	Hardware and Software Integration
HTC	Human Tended Capability
HW	Hardware
HWCI	Hardware Configuration Item
I&CO	Integration & Checkout
I&V	Integration and Verification
I&VIP	Integration and Verification Implementation Plan

ICD	Interface Control Document
ICDR	Informal Critical Design Review
IDL	Intersite Delivery List
IDR	Interim Design Review
IACO	Integration, Assembly and Checkout
I/F	Interface
IGA	Intergovernmental Agreement
IOS	Integrated Operations Scenario
IOSS	International On–orbit Space Station
IP	International Partner
IPDR	Informal Preliminary Design Review
IPT	Integrated Product Team
IRD	Interface Requirements Document
IREC	Ionizing Radiation Environmental Capability
ISPR	International Standard Payload Rack
ISRT	Independent Safety Review Team
ISSA	International Space Station Alpha
ITCO	Integrated Test and Checkout
IV&V	Independent Verification and Validation
IVA	Intravehicular Activity
IVLN	Integrated Verification Logic Network
IVVR	Integrated Verification Visibility Report
JEM	Japanese Experiment Module
JIVP	Joint Integration and Verification Plan
JMP	Joint Management Plan
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LCN	Logistics Control Number
LMSC	Lockheed Missile and Space Company
LP	Launch Processing
LSAR	Logistics Support Analysis Record
MATE	MDM Application Test Environment

MDC	McDonnell Douglas Aerospace
MB	Mission Build
MBS	Mission Build Facility
MBS	Mobile Base System
MDM	Multiplexer/DeMultiplexer
MES	Management Emphasis System
MI&VP	Master Integration and Verification Plan
MIL–STD	Military Standard
MOA	Memorandum of Agreement
MOD	Missions Operations Directorate
MOU	Memorandum of Understanding
MPLM	Mini–pressurized Logistics Module
MRS	Mobile Remote Servicer
MSFC	Marshall Space Flight Center
MSS	Mobile Servicing System
MVP	Master Verification Plan
MT	Mobile Transporter
N1	Node 1
N2	Node 2
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan
NSTS	National Space Transportation System
OA	Orbital Assembly
OACO	On–orbit Assembly and Checkout
O/D	On–dock
ODF	Operations Data File
ODRC	Orbiter Data Reduction Complex
OMI	Operations and Maintenance Instruction
OMRS	Operations and Maintenance, Requirements and Specification
OPF	Orbiter Processing Facility
ORR	Operations Readiness Review
ORU	Orbital Replacement Unit
OSD	Operational Sequence Diagram
OSE	Orbital Support Equipment

PAI	Payload Analytical Integration
PAIT	Program Analysis and Integration Team
PCA	Physical Configuration Audit
PCR	Payload Changeout Room
PDCO	Post Delivery Checkout
PDMS	Payload Data Management System
PDR	Preliminary Design Review
PDV	Post Delivery Verification
PEP	Program Execution Plan
PES	Payload Executive Software
PFM	Program Furnished Material
PG	Product Group
PI	Payload Integration
PIA	Project Implementation Agreement
PIDS	Prime Item Development Specification
PIVP	Prime Integration and Verification Plan
PL	Payload
PMA	Pressurized Mating Adaptor
PMI&VP	Program Master Integration and Verification Plan
PMO	Program Management Office
PODF	Payload Operations Data File
POS	Payload Operations Support
PP&C	Program Planning and Control
PRACA	Problem Reporting and Corrective Action
PT	Processing Team
PVIS	Program Verification Information System
PVPP	Payload Verification Program Plan
P/N	Part Number/Name
QA	Quality Assurance
QFA	Quantative Functional Analysis
RBDA	Reliability Block Diagram Analysis
RDD–100	Requirements Driven Development (S/W Tool)
RI	Rockwell International
RMM	Reboost and Maneuver Module
ROD	Review of Design

RRS	Russian Rescue System
RS	Russian Segment
RSA	Russian Space Agency
RSS	Root Sum Square
RCV	Receive
RTM	Requirements and Traceability Management
SAR	Safety Analysis Report
SAIT	System Analysis and Integration Team
SCN	Specification Change Number
SDP	Software Development Plan
SDR	System Design Review
SDRL	Subcontract Data Requirements List
SDS	Sample Delivery Subsystem
SE	Support Equipment
SE&I	Systems Engineering and Integration
SODF	System Operations Data File
SOW	Statement of Work
SM	Service Module
SM&C	Station Management & Control
SPDM	Special Purpose Dextrous Manipulator
SPP	Science Power Platform
SRMQA	Safety, Reliability, Maintainability, and Quality Assurance
SRR	System Requirements Review
SRS	Software Requirement Specification
SSAIT	Space Station Analysis and Integration Team
SSCB	Space Station Control Board
SSMB	Space Station Manned Base
SSOS	Space Station Operations Support
SSP	Space Station Program
SSPF	Space Station Processing Facility
SSRMS	Space Station Remote Manipulator System
STA	Structural Test Article
STD	Software Test Description
S&M	Structures and Mechanisms
S&MA	Safety and Mission Assurance
S&U	Science and Utilization

STE	Special Test Environment
STP	Software Test Plan
STR	Software Test Report
STS	Space Transportation System
SVF	Software Verification Facility
SW	Software
TBD	To Be Determined
TEP	Team Execution Plan
TPEP	Transition Program Execution Plan
TSE	Test Support Equipment
TTA	Technical Task Agreement
UDM	Universal Docking Module
US	United States
USGS	US Ground Segment
USOO	US On–orbit
USOS	US On–orbit Segment
VAB	Vehicle Assembly Building
VAIT	Vehicle Analysis and Integration Team
VCN	Verification Closure Notice
VCRI	Verification Cross Reference Index
VER	Verification
VIMS	Verification Information Management System
VLN	Verification Logic Network
VMDB	Vehicle Master Database
VO	Verification Objective(s)
VPF	Vertical Processing Facility
VR	Verification Requirement
V&V	Verification and Validation
VTS	Verification Tracking System
WAD	Work Authorization Document
XMIT	Transmit

APPENDIX B DEFINITION

Following are definitions of the more important terms used in this plan, listed in alphabetical order.

1. Acceptance – Provides assurance that an item was manufactured as designed and free of manufacturing and workmanship defects.
2. Analysis – A verification method utilizing techniques and tools such as math models, compilation, similarity assessments, and validation of records to confirm that verification requirements have been satisfied.
3. Analytical Model – A mathematical representation of a hardware and/or software item with input and output values which have a direct correspondence to the measurements, performance, and observations of that item.
4. Assembly and Checkout – The activities required to integrate ISSA end items into on–orbit stages and ensure they support operational readiness.
5. Cargo Element – A group of station flight hardware end items and any associated Flight Support Equipment, configured into a single entity for transport to orbit in the Orbiter payload bay.
6. Certificate of Flight Readiness – A formal document that attests certification to support delivery to orbit.
7. Certification – The formal written act whereby a responsible official attests to the satisfactory accomplishment of specified activities and authorizes the specified hardware/software, procedures, facilities and/or personnel for program usage.
8. Configuration Item – Hardware or software, or an aggregation of both, which is designated by the contracting agency for configuration management.
9. Demonstration – A method of verification denoting the qualitative determination of properties of an end–item or component by observation. Demonstration is used with or without special test equipment or instrumentation to verify requirements characteristics.
10. Development Tests – Development Tests are tests performed with minimum rigor and controls to prove a design approach. Included are tests performed to minimize technical risks and to assist in design engineering activities. These tests encompass material selection, design tolerance verification, and identification of operational characteristics. These tests are usually performed by the engineering organization.
11. End Item – A combination of parts, assemblies, accessories, and/or attachments integrated to form an equipment unit that will accomplish a specific function when used. An end item is complete within itself and classified as such for purposes of separate manufacture, procurement, drawings, specifications, storage, issue, maintenance, or use. Deliverable component(s) of the Station that helps make up a launch package.
12. Facility –Physical plant, consisting of real estate and improvements, including buildings and associated equipment.
13. Ground Support Equipment – GSE is contract–deliverable equipment (hardware/software) used on the ground to test, transport, access, handle, maintain, measure, verify, service, and protect flight hardware/software. This includes GFE which is delivered to, or received from, other work package contractors to support acceptance testing and/or IACO.
14. Independent Verification and Validation – Verification and validation of software products by an organization that is both technically and managerially separate from the organization responsible for developing the product.

15. Inspection – A method of verification of physical characteristics that determines compliance without the use of special laboratory equipment, procedures, test support items, or services. Inspection uses standard methods such as visuals, gauges, etc., to verify compliance with requirements.
16. Integration – The act of mating hardware and/or software components, subsystems, systems, or elements with their respective interfaces and verifying the compatibility and proper operation of the resulting entity.
17. Launch Package Processing – Configuration the activities performed to process end items into cargo element configurations and Cargo elements for a launch package. Processing includes closeouts, launch package integration, weight and CG assessments, and Shuttle payload I/F/O checkout.
18. Launch Processing – All activities that occur at the launch site from on–deck to launch.
19. On–Orbit Configuration – Hardware and software configurations which exist during assembly operation, including stage configurations.
20. Orbital Assembly – A collection of hardware and software integrated prior to launch, transported to orbit as a unit, and assembled as a unit into an on–orbit configuration.
21. Orbital Replacement Unit – A component or subsystem hardware item that is designated by the Product Group or International Partner and approved at the systems/subsystems CDR to be removed and replaced under orbital conditions, which has not been designated as an Additional Maintenance Item.
22. Pre–Declaration – Notification of intent to use data from a development test to support qualification. Approval of Prime (for subcontractor’s pre–declaration) and/or NASA (for Prime’s pre–declaration) is required prior to start of test.
23. Protoflight – Use of flight hardware during ground qualification testing in lieu of a dedicated test article.
24. Qualification – The activity that proves design, manufacturing and assembly have resulted in hardware and software that conforms to design and performance requirements when subjected to specific environmental conditions.
25. Specification Compliance – Specification compliance consists of two related activities. 1) Activities that support the verification of Program (Systems and Segment) A and B1 specifications (PID documentation), and 2) Activities to consolidate and review all qualification and acceptance data to ensure all requirements are satisfactorily met.
26. Stage – The aggregate of flight hardware and software that defines the on–orbit configuration of the space station at the time of NSTS departure associated with an assembly flight.
27. Subassembly – A group of components.
28. Test – A method of verification wherein requirements are verified by measurement during or after the controlled application of functional and environmental stimuli. These measurements may require the use of laboratory equipment, recorded data, procedures, test support items, or services.
29. Validation – A set of activities performed to ensure that each product reflects an accurate interpretation and execution of requirements and meets a level of functionality and performance that is acceptable to users.
30. Verification – A set of activities performed to ensure that facilities, hardware and software products, and operational procedures comply with the specification requirements imposed on them.